Permit

Environmental Protection Act 1994

Environmental Authority -

This environmental authority is issued by the administering authority under Chapter 5 of the Environmental Protection Act 1994.

Environmental authority number: P-EA-100121435

Environmental authority takes effect on the day of approval.

The anniversary date of this environmental authority remains **16 December**. The payment of the annual fee will be due each year on this day.

Environmental authority holder

Name	Registered address
SRCP (Shoreline) Pty Ltd	Level 25, 133 Castlereagh Street Sydney NSW 2000

Environmentally relevant activity and location details

Environmentally relevant activity	Locations
ERA 63 - Sewage Treatment 1(e) - Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of more than 10,000 but not more than 50,000EP	Lot 1 on SP344900, Lot 4 on SP344900, Lot 83 on S312432, Lot 84 on S312432, Lot 86 on S312432, Lot 255 on S312432, Lot 256 on S312432, Lot 257 on S312432 and Lot 259 on S312432

Additional information for applicants

Environmentally relevant activities

The description of any environmentally relevant activity (ERA) for which an environmental authority (EA) is issued is a restatement of the ERA as defined by legislation at the time the EA is issued. Where there is any inconsistency between that description of an ERA and the conditions stated by an EA as to the scale, intensity or manner of carrying out an ERA, the conditions prevail to the extent of the inconsistency.

An EA authorises the carrying out of an ERA and does not authorise any environmental harm unless a condition stated by the EA specifically authorises environmental harm.

A person carrying out an ERA must also be a registered suitable operator under the *Environmental Protection Act 1994* (EP Act).

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Contaminated land

It is a requirement of the EP Act that an owner or occupier of land give written notice to the administering authority if they become aware of the following:

- the presence of, or happening of an event involving, a hazardous contaminant on the land that is causing, or is reasonably likely to cause, serious or material environmental harm (notice must be given within 24 hours); or
- if the land is contaminated land – a change in the condition of the land that is causing, or is reasonably likely to cause, serious or material environmental harm (notice must be given within 24 hours); or
- a notifiable activity (as defined in Schedule 3) having been carried out, or is being carried out, on the land (notice must be given within 20 business days).

For further information, including the form for giving written notice, refer to the Queensland Government website www.qld.gov.au, using the search term 'duty to notify'.

Take effect

Please note that, in accordance with section 200(1) of the EP Act, an EA has effect:

(a) if the authority is for a prescribed ERA and it states that it takes effect on the day nominated by the holder of the authority in a written notice given to the administering authority—on the nominated day; or

(b) if the authority states a day or an event for it to take effect—on the stated day or when the stated event happens; or

(c) otherwise—on the day the authority is issued.

However, in accordance with section 200(2) of the EP Act, the day that the EA takes effect may not be before:

(a) if the authority is for a resource activity—the day the relevant tenure is granted to the applicant; or

(b) if a development permit for a material change of use of premises under the *Planning Act 2016* is necessary for carrying out an activity that related to the authority—the day the development permit takes effect; or

(c) if an SDA Approval under the *State Development and Public Works Organisation Act 1971* is necessary for carrying out an activity that relates to the authority—the day the approval takes effect.

If this EA takes effect when the additional authorisation takes effect, you must provide the administering authority written notice within 5 business days of receiving notification of the related additional authorisation taking effect.

If you have incorrectly claimed that an additional authorisation is not required, carrying out the ERA without the additional authorisation is not legal and could result in your prosecution for providing false or misleading information or operating without a valid EA.

	07/09/2026
Signature	Date

Rebecca Griffiths

Department of the Environment, Tourism, Science and Innovation
Delegate of the administering authority
Environmental Protection Act 1994

Enquiries:

Utilities and Government Organisations Assessment
GPO Box 2454, Brisbane, QLD 4001
Phone: 1300 130 372
Email: palm@des.qld.gov.au

Obligations under the *Environmental Protection Act 1994*

In addition to the requirements found in the conditions of this EA, the holder must also meet their obligations under the EP Act, and the regulations made under the EP Act. For example, the holder must comply with the following provisions of the Act:

- general environmental duty (section 319)
- duty to restore the environment (section 319C)
- duty to notify environmental harm (section 320-320G)
- offence of causing serious or material environmental harm (sections 437-439)
- offence of causing environmental nuisance (section 440)
- offence of depositing prescribed water contaminants in waters and related matters (section 440ZG)
- offence to place contaminant where environmental harm or nuisance may be caused (section 443).

Other permits required

This permit only provides an approval under the EP Act. In order to lawfully operate you may also require permits / approvals from your local government authority, other business units within the department, and other State and Federal Government agencies prior to commencing any activity at the site. For example, this may include permits or approvals with your local Council (for planning approval), the Department of Transport and Main Roads (to access State controlled roads), the Department of Natural Resources and Mines, Manufacturing, and Regional and Rural Development (to clear vegetation), and the Department of Primary Industries (to clear marine plants or to obtain a quarry material allocation).

Obligations under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)

Matters of national environmental significance (MNES) are regulated under the Commonwealth EPBC Act rather than under state legislation. You may need to submit a referral if your project potentially impacts any matters protected under the EPBC Act. For more information on self-assessments, and referral and assessment processes, please visit the Australian Government Department of Climate Change, Energy, the Environment and Water's website at www.dcceew.gov.au/environment/epbc/advice.

Obligations under the *Mining and Quarrying Safety and Health Act 1999*

If you are operating a quarry, other than a sand and gravel quarry where there is no crushing capability, you will be required to comply with the *Mining and Quarrying Safety and Health Act 1999*. For more information on your obligations under this legislation, visit Resources Safety and Health Queensland's website at www.rshq.qld.gov.au, or call 13 QGOV (13 74 68) or your local Mines Inspectorate Office.

Development approval

This permit is not a development approval under the *Planning Act 2016*. The conditions of this EA are separate, and in addition to, any conditions that may be on the development approval. If a copy of this EA is attached to a development approval, it is for information only and may not be current. Please contact the Department of the Environment, Tourism, Science and Innovation to ensure that you have the most current version of the EA relating to this site.

Obligations under the *Aboriginal Cultural Heritage Act 2003* and *Torres Strait Islander Cultural Heritage Act 2003* (the Cultural Heritage Acts)

The Cultural Heritage Acts require anyone who carries out a land-use activity to exercise a duty of care. This 'duty of care' means land users must take all reasonable and practicable measures to ensure their activity does not harm Aboriginal or Torres Strait Islander cultural heritage, and applies to any activity where Aboriginal or Torres Strait Islander cultural heritage is located. For more information on your obligations under this legislation, please visit the Department of Women, Aboriginal and Torres Strait Islander Partnerships and Multiculturalism webpage at, www.dwatsipm.qld.gov.au.

Conditions of environmental authority

Southern Redland Bay Wastewater Treatment Plant

Environmentally relevant activity	Locations
ERA 63 - Sewage Treatment 1(e) - Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of more than 10,000 but not more than 50,000EP	Lot 1 on SP344900, Lot 4 on SP344900, Lot 83 on S312432, Lot 84 on S312432, Lot 86 on S312432, Lot 255 on S312432, Lot 256 on S312432, Lot 257 on S312432 and Lot 259 on S312432

The environmentally relevant activity conducted at the location as described above must be conducted in accordance with the following site-specific conditions of the approval.

Agency interest: General	
Condition number	**Condition**
G1	Daily inflows into the sewage treatment plant, located on Lot 1 on SP344900 in accordance with *Appendix 1, Site layout ERA 63*, must not exceed the following on any **day** unless the standard treatment processes of the sewage treatment plant are **bypassed**: (a) The daily peak design capacity of 5 times the **Design Average Dry Weather Flow** (**DADWF**) of 1.35 ML/day, being 6.75 ML/day in total, during **Stage 1**; or (b) The daily peak design capacity of 3 times the **DADWF** of 2.7 ML/day, being 8.1 ML/day in total, during **Stage 2**.
G2	All reasonable and practicable **measures** must be taken to prevent or minimise any environmental harm caused, or likely to be caused by the **activities**.
G3	Any breach of a condition of this environmental authority must be reported to the **administering authority** as soon as practicable within 24 hours of becoming aware of the breach. **Records** must be kept including full details of the breach and any subsequent actions taken.
G4	Other than as permitted by this environmental authority, the **release of a contaminant into the environment** must not occur.
G5	All information and **records** required by the conditions of this environmental authority must be kept for a minimum of five years with the exception of environmental **monitoring** results which must be kept until surrender of this environmental authority. All information and **records** required by the conditions of this environmental authority must be provided to the **administering authority** upon request and in the format requested.
G6	An **appropriately qualified person(s)** must **monitor**, record and interpret all parameters that are required to be **monitored** by this environmental authority and in the manner specified by this environmental authority.

G7	All analyses required under this environmental authority must be carried out by a laboratory that has National Association of Testing Authorities **(NATA)** accreditation or an equivalent certification, for such analyses. The only exception to this condition is for in situ **monitoring** of pH, dissolved oxygen, electrical conductivity, turbidity, ammonia, chlorophyll-a and chlorine.
G8	You must record the following details for all **environmental complaints** received: (a) date and time complaint was received; and (b) name and contact details of the complainant when provided (c) nature of the complaint; and (d) investigations undertaken; and (e) conclusions formed; and (f) actions taken.
G9	When required by the **administering authority**, **monitoring** must be undertaken in the manner informed by an **appropriately qualified person** and within a reasonable timeframe prescribed by the **administering authority** to investigate alleged environmental nuisance or environmental harm caused by the **activities**. The **monitoring** results must be provided within 10 business days to the **administering authority** upon its request or another period agreed to in writing by the **administering authority**.
G10	The **activity** must be undertaken in accordance with written procedures that: (a) identify potential risks to the environment from the **activity** during routine operations, closure and an emergency; and (b) establish and maintain control **measures** that minimise the potential for environmental harm; and (c) ensure plant, equipment and **measures** are maintained in a proper and effective condition; and (d) ensure plant, equipment and **measures** are operated in a proper and effective manner; and (e) ensure that staff are trained in and aware of their obligations under *the Environmental Protection Act 1994*; and (f) ensure that reviews of environmental performance are undertaken at least annually.
G11	Chemicals and fuels in containers of greater than 15 litres must be stored within a **secondary containment system.**
G12	An annual monitoring report must be prepared and submitted to the **administering authority** by 30 November each year, for the preceding financial year.
G13	**Effluent** may be removed from the **site** and provided to a **person** with the written consent of that **person**.

G14	**Records** of treated **effluent** removed from the **site** and supplied to a **person** must be made and include the following: (a) the **person** the **effluent** was supplied to; and (b) the *Escherichia coli* (E.coli) (cfu/100mL) concentration of the **effluent** supplied; and (c) the volume of **effluent** supplied; and (d) the date the **effluent** was supplied.
G15	Immediately upon the request of the **administering authority**, **you** must cease providing **effluent** to a **person**.
Agency interest: Air	
Condition number	**Condition**
A1	Odours or airborne contaminants from the **activity** must not cause environmental nuisance to any **sensitive place** or **commercial place**.
A2	Odourous emissions from the inlet works, the screenings and grit bins, the bioreactor anaerobic zone, and the feed averaging tank must: (a) be extracted and treated to reduce odour prior to release; and (b) only be released to air from the point source Release Point A1 in accordance with Table 3.1 – Point source air release locations and the associated requirements. **Table 3.1 – Point source air release locations** **Release point description** | **Release location** Release Point A1 | Odour control facility stack **Associated requirements** 1. The release of contaminants from a point source must be directed vertically upwards without any impedance or hindrance.
Agency interest: Noise	
Condition number	**Condition**
N1	Noise generated by the **activity** must not cause environmental nuisance to any **sensitive place** or **commercial place.**

Agency interest: Water	
Condition number	**Condition**
WT1	Other than as permitted within this environmental authority, contaminants must not be released to any **waters**.
WT2	Contaminants generated by the **activity**, other than those in **bypass** releases covered by conditions WT3 and WT4, must only be released to discharge location **W1** where the following requirements are complied with: (a) the contaminants being released comply with the release limits for each quality characteristic specified in *Table 3.3 – Contaminant limits for releases to surface water* (b) the contaminants being released are **monitored** at their minimum **monitoring** frequency for each quality characteristic specified in *Table 3.3 – Contaminant limits for releases to surface water*; and (c) the associated requirements below *Table 3.3 – Contaminant limits for releases to surface water* are complied with and **records** that demonstrate that compliance are made.

Table 3.3 – Contaminant limits for releases to surface water

Monitoring location	**Quality Characteristic (units)**	**Release limit**						**Minimum monitoring frequency**
		Mini-mum	**Long-term median**	**Short-term median**	**Long term 90th per-centile**	**Long term 95th per-centile**	**Maxi-mum**	
Overflow outlet of the Chlorine Contact Tank	Daily volume (L/**day**)	-	-	-	-	-	-	Daily
	E.Coli (organisms/100mL)	-	-	-	-	-	10	Weekly
	Total Nitrogen TN (mg/L)	-	3	6	-	-	9	Weekly
	Ammonia (mg/L as N)	-	-	-	-	-	3	Weekly
	Total Phosphorus TP (mg/L)	-	1	2	-	-	3	Weekly
	BOD_5 (mg/L)	-	-	-	10	-	20	Weekly
	Total Suspended Solids (mg/L)	-	23	-	-	-	50	Weekly
	Filterable reactive phosphorus (FRP)	-	-	-	-	-	-	Weekly

Overflow outlet of the Chlorine Contact Tank	pH (pH units)	6.5	-	-	-	-	8.5	Weekly
	Annual volume (ML/year)	-	-	-	-	-	--	Annually
	Annual mass load TN (tonnes/year) – **Stage 1**	-	-	-	-	-	1.5	Annually
	Annual mass load TP (tonnes/year) – **Stage 1**	-	-	-	-	-	0.5	Annually
	Annual mass load TN (tonnes/year) – **Stage 2**	-	-	-	-	-	3	Annually
	Annual mass load TP (tonnes/year) – **Stage 2**	-	-	-	-	-	1	Annually
Effluent Manhole 1	Free Chlorine (mg/L)	-	-	-	-	-	0.7	Weekly
	Total Chlorine (mg/L)	-	-	-	-	-	-	Weekly
Effluent Manhole 2	Dissolved Oxygen (mg/L)	2	-	-	-	-	-	Weekly
Turbidity analyser	Turbidity (NTU)	-	-	-	-	2	5	Weekly
MOA M1	Total Chlorine (mg/L)	-	-	-	-	-	0.1	Weekly

Associated requirements

1. Water samples must be representative of the general condition of the release; and
2. The **limit of reporting** for all **monitoring** tests required by condition WT2 must be less than the release limit; and
3. **Long-** and **short-term median** values must be calculated on a rolling basis; and
4. Samples for **monitoring** for **Total Nitrogen** and **Total Phosphorus** must be taken as **composite samples**; and
5. **TN** and **TP monitoring** must include consecutive samples that are taken on a weekly basis of approximately equal periods, where the time interval is not less than six days; and
6. The mass load of **TN** and **TP** released to **waters** must be calculated weekly and **records** of this calculation must be kept. Mass load must be calculated as: (the sum of daily release volume (ML) over the week) x (**monitored** TN/TP concentration (mg/L)).
7. The **annual mass load**s of **TN** and **TP released to waters** must be calculated on a rolling weekly basis.
8. Ammonia, Nitrate (NO_3^--N), Nitrite (NO_2^--N) and Filterable Reactive Phosphorus (FRP) must be measured when **Total Nitrogen** and Total Phosphorus are **monitored**; and
9. Water quality monitoring must be in accordance with the methods prescribed in the current edition of the **administering**

	authority's Monitoring and Sampling Manual; and 10. Volume monitoring for releases to the **lagoon** must be undertaken using a calculated flow measurement derived from flow meters installed on **contributing flow paths**, where: a. volumes measurements are accurate; b. all inflows to the **lagoon** are continuously **monitored**; c. the calculation methodology is automated via the plant control system (PLC); d. the methodology accounts for all flow paths contributing to the **lagoon**; and e. **records** of volume, date and time of releases are maintained. 11. At locations where **composite sampling** is required, if there is no measurable flow at these locations sampling is not required to be undertaken for the period that there is no flow. However, once flow resumes if the required time-period between aliquots has elapsed a sample should be taken immediately. 12. For the monitoring location "Overflow outlet of the Chlorine Contact Tank", **composite samples** are only required to be taken when the flow is being directed to the surface **waters** (location **W1**). i.e. When flow is being directed from the Chlorine Contact Tank overflow to the recycled water storage tank **composite samples** are not required to be taken.
WT3	**Bypass** releases must be screened prior to being released.
WT4	The **administering authority** must be notified within 24 hours of any **bypass** release commencing and ceasing.
WT5	The following details must be recorded in relation to each **bypass** release and included in the notification after ceasing as required by condition WT4: (a) the start time, date and duration of the release; and (b) the estimated volume of the **bypass** release; and (c) the level of treatment at the sewage treatment plant prior to discharge; and (d) the reason the release needed to occur; and (e) any **monitoring** of the **effluent** quality released.
WT6	Releases to surface **waters** must not produce any slick or other visible evidence of oil or grease, nor contain visible floating oil, grease, scum, litter or other visually objectionable matter.
WT7	The **lagoon** must: (a) be certified by an **appropriately qualified person** to the extent of modifications to the pre-existing structure, upon the completion, and (b) be constructed so as to prevent inundation from floodwaters up to and including a 50 year ARI flood event; and (c) be constructed with a spillway.
WT8	An **appropriately qualified person** must develop and implement an Algae Management Plan for the **lagoon**. This plan must include: (a) identification of conditions in the **lagoon** likely to promote algal blooms; and (b) mitigation **measures** implemented in the **lagoon** to prevent the formation of algal blooms; and

	(c) **monitoring** requirements for the **lagoon** to determine the impact of algal blooms on water quality, where algal blooms are occurring. This must include **monitoring** of pH, suspended solids and chlorophyll-*a* (to determine algae biomass), and a determination of the level of toxicity of the algae in the bloom in relation to likelihood of causing adverse impacts to environmental values upon release; and (d) mitigation **measures** to be undertaken to reduce or remove algal blooms from **lagoon** should algal blooms form; and
WT9	One of the following options must be undertaken: (a) conduct a Water Receiving Environment Monitoring Program (WREMP) in accordance with conditions WT11 to WT22 inclusive; or (b) become and remain a participating member in a study carried out by other **persons** or agencies that meets the requirements of conditions WT11 to WT15 inclusive (the equivalent study).
WT10	Where you have become a participating member in a study in accordance with condition WT9, you must keep **records** of: (a) your participation in the study; and (b) the results of the study insofar as they relate to the **activity**.
WT11	In accordance with condition WT9, a Water Receiving Environment Monitoring Program (WREMP) must be: (a) designed by an **appropriately qualified person** with experience and qualifications in water **monitoring**, to **monitor** the effects of the **activity** on **waters**; and (b) reviewed annually by an **appropriately qualified person** and certified as being appropriate to meet the requirements in condition WT12 to WT13.
WT12	The WREMP required by condition WT11 must include: (a) clearly stated aims and objectives; and (b) a monitoring program that is developed using the latest version of the **administering authority's** *Receiving Environment Monitoring Program Guideline* (ESR/2016/2399), and specify: (i) **environmental values** of the **receiving waters**; and (ii) cumulative impacts on the **receiving waters**; and (iii) the spatial extent of the monitoring program, including the location of **monitoring** sites; and (iv) **t**he temporal context of the monitoring program, including the timing and frequency for sampling.
WT13	The WREMP required by condition WT11 must include **monitoring** of the receiving environment at the monitoring location(s), and at the minimum monitoring frequency, and for the quality characteristics specified in *Table 3.5 – WREMP.*

<table>
<tr><td></td><td>

Table 3.5 – WREMP

<table>
<tr><th>Monitoring locations</th><th>Quality characteristic (units)</th><th>Minimum monitoring frequency</th></tr>
<tr><td rowspan="7">Upstream, downstream, and at the release point of the offsite nutrient reduction action.</td><td>BOD₅ (mg/L)</td><td rowspan="7">Monthly</td></tr>
<tr><td>Total Suspended Solids (mg/L)</td></tr>
<tr><td>Total Phosphorus TP (mg/L)</td></tr>
<tr><td>Total Nitrogen TN (mg/L)</td></tr>
<tr><td>pH (pH units)</td></tr>
<tr><td>Dissolved Oxygen (mg/L)</td></tr>
<tr><td>Chlorophyll a</td></tr>
</table>

</td></tr>
<tr><td>WT14</td><td>The monitoring program required by condition WT11 must be designed to monitor the effects of the activity on the receiving environment while effluent is being discharged from the site, and comply with the following requirements:
(a) monitoring must be undertaken at control locations that are suitable for establishing a background or other referable environmental value for the receiving waters; and
(b) monitoring must be undertaken at test locations that are suitable for determining the extent to which the receiving waters are, or are potentially, being impacted by the activity; and
(c) sampling must not occur in periods where the receiving water level is higher than its base flow level.</td></tr>
<tr><td>WT15</td><td>The WREMP required by condition WT11 must include:
(a) the development of trigger values for the receiving waters; and
(b) procedures to determine when trigger values are reached; and
(c) the development of management actions to mitigate any adverse impacts caused, or likely to be caused, the activity; and
(d) the implementation of the management actions if a WREMP trigger value is reached.</td></tr>
<tr><td>WT16</td><td>The WREMP required by condition WT11 must be submitted to the administering authority upon request and within a timeframe (which must be at least 5 business days) specified by the administering authority.</td></tr>
<tr><td>WT17</td><td>Any comments made by the administering authority on the WREMP must be addressed to the reasonable satisfaction and within a timeframe (which must be at least 10 business days) specified by the administering authority.</td></tr>
</table>

WT18	A report summarising the results of the WREMP or the equivalent study (WREMP Report) must be prepared by an **appropriately qualified person** and submitted to the **administering authority** with the Annual Monitoring Report as required under condition G12.
WT19	The WREMP Report required by condition WT18 must include: (a) a summary of the previous 12 months **monitoring** data obtained under the WREMP in the relevant financial year; and (b) an evaluation of all relevant data obtained under the WREMP, including graphical representations showing all historical data and a comparison of data trends against WREMP **trigger values**; and (c) a description of all actions taken to minimise the environmental risk in response to data or other information obtained during from the WREMP, including actions taken where WREMP **trigger values** were reached; and (d) the results of those management actions.
WT20	The WREMP Report required by condition WT18 must include analysis and interpretation of the data and other information obtained through the implementation of the WREMP that determines how the **receiving waters** have been impacted by the **activity** and the **offsite nutrient reduction action.**
WT21	The WREMP Report required by condition WT18 must include recommended action(s) to mitigate any adverse impacts caused, or likely to be caused, by the **activity** in respect of contaminant releases to surface **waters**.
WT22	The action(s) required under condition WT21 in the WREMP Report must be commenced: (a) if such action(s) are a reasonable response to minimise the environmental risk identified; and (b) as soon as practicable, but no more than 14 **days** after receiving the WREMP monitoring report; or (c) another period agreed to in writing by the **administering authority**.
WT23	A release of contaminants to **waters** reduction strategy must be developed and implemented, and must include the following: (a) clearly stated aims, objectives, and timeframes; and (b) investigation of beneficial re-use and land application opportunities for treated **effluent**; and (c) implementation of **measures** to reduce the volume of treated **effluent** that is released to **waters**.
WT24	Progress on the implementation of the release reduction strategy must be included in the annual monitoring report required by condition G12 including, but not limited to, information on: (a) beneficial re-use and land application opportunities investigated and implemented; and (b) the volumes of treated **effluent** that are provided to third party users, released to **land**, and released to **waters** from the **activity**.

Agency interest: Offset	
Condition number	**Condition**
O1	From **beginning of releases to waters** you must achieve at least 150% **nutrient offset** of the **Total Nitrogen** load of all releases from the **activity** to **waters**.
O2	The yearly sum of daily release volume (ML) and **annual mass load** and **annual mass load (offset)** of **Total Nitrogen** and **total phosphorus** released to **waters** must be calculated for each financial year.
O3	An **offsite nutrient reduction action** must be undertaken in accordance with the document entitled *Southern Redland Bay WWTP – Mangrove Design and Receiving Environmental Assessments for the Infrastructure Designation Process*, Revision 3 (Lendlease Communities (Shoreline) Ltd 11.02.2021).
O4	Prior to the use of the proposed **offsite nutrient reduction action** under condition O3, the following baseline **monitoring** must be undertaken by an **appropriately qualified person**: (a) an ecological assessment, to ensure that the mangrove and saltmarsh is established and biologically functioning; and (b) **monitoring** of water quality within the **MOA** for at least one year prior to any anticipated releases of contaminants into the **MOA**.
O5	A report summarising the results of the baseline **monitoring** required by condition O4 must be prepared by an **appropriately qualified person** and submitted to the **administering authority** with the Annual Monitoring Report as required under G12.
O6	A report reviewing the effectiveness of the **offsite nutrient reduction action** must be prepared by an **appropriately qualified person,** and submitted to the **administering authority** annually with the Annual Monitoring Report as required under G12.
O7	The report required by condition O6 must: (a) be based on **monitoring** results obtained during the delivery of the **offsite nutrient reduction action**; and (b) make reference to relevant results of routine **monitoring** of releases from **W1** obtained under requirements of condition WT2; and (c) make reference to relevant results of the **receiving environment monitoring program** required under condition WT11; and (d) include a determination of mangrove growth and/or health, based on **monitoring** such as aerial imagery and repeatable transect surveys; and (e) determine if the delivery of the **offsite nutrient reduction action** has been effective in preventing or mitigating harm from releases of nutrients from the **activity** on the receiving environment; and (f) determine if the requirements of condition O1 have been complied with; and (g) if the requirements of condition O1 have not been complied with, provide recommendations for actions to be taken to improve the performance of the **offsite nutrient reduction action**.

Agency interest: Land	
Condition number	**Condition**
L1	The only contaminants to be released to **land** are treated sewage **effluent** in accordance with Table 3.2 - Contaminant limits for releases to **land** and the associated requirements.

Table 3.2 - Contaminant limits for releases to land.

Monitoring location	**Discharge locations**	**Quality Characteristic (units)**	**Release limits**					**Minimum monitoring frequency**
			Mini-mum	**Aver-age**	**Long-term median**	**Short-term median**	**Maxi-mum**	
Overflow outlet of the Chlorine Contact Tank	**Effluent disposal areas**	Irrigation volume (L/**day**)	-	-	-	-	-	Daily
		Irrigation rate (mm/**day**)	-	2.5	-	-	5	
	Irrigation areas	Irrigation volume (L/**day**)	-	-	-	-	-	
		Irrigation rate (mm/**day**)	-	-	-	-	10	
	Effluent disposal areas and **irrigation areas**	**Total Nitrogen TN** (mg/L as N)	-	-	3	6	9	Weekly
		Total Phosphorus TP (mg/L as P)	-	-	1	2	3	
		pH (pH units)	6.5	-	-	-	8.5	
		Escherichia coli (E.coli) cfu/100mL)	-	-	-	-	10	
		Electrical Conductivity (EC) (µS/cm)	-	-	-	-	1400	

Associated requirements 1. **Monitoring** must only be undertaken when **effluent** is being released to **land**; and 2. The **limit of reporting** for all **monitoring** tests required by condition L1 must be less than the release limit; and 3. The irrigation rate **monitoring** must be calculated based on the total area irrigated on that **day**, and the actual volume of **effluent** irrigated on that same **day**; and 4. **Long-** and **short-term median** values must be calculated on a rolling basis; and 5. **TN** and **TP monitoring** must include consecutive samples that are taken on a weekly basis of approximately equal periods, where the time interval is not less than six **day**s; and 6. Water quality **monitoring** must be in accordance with the methods prescribed in the current edition of the **administering authority's** Monitoring and Sampling Manual; and 7. Volume **monitoring** must be undertaken using a flow meter.	
L2	**Records** must be kept of all areas used as **effluent disposal areas.**
L3	Wet weather storage with a minimum volume of 1.6 ML must be installed and maintained on the **site** for the storage of **effluent.**
L4	When weather conditions or soil conditions preclude the release of treated sewage **effluent** to **land**, **effluent** must not be irrigated to **land**.
L5	When soil in the **effluent disposal areas** and **irrigation areas** is **saturated**, **effluent** must not be released to **land**.
L6	Ponding of contaminants within the **effluent disposal area** must not occur.
L7	Contaminants must not run off to areas beyond the **effluent disposal area**.
L8	Soil structure must not be degraded as a result of the **activity**
L9	Soil sodicity and the build-up of nutrients and heavy metals in the soil and subsoil must be minimised.
L10	The **effluent disposal area** must be maintained with an appropriate crop in a **viable state.**
L11	Reuse of treated sewage **effluent** for dust suppression must be done through low pressure dispersion (e.g. gravity-fed 'dribble bar').
Agency interest: Waste Management	
Condition number	**Condition**
W1	All waste generated by the **activity** must be lawfully reused or recycled or removed to a facility that can lawfully accept the waste.

Definitions

Where a word or phrase in this document is **bolded**, it has its corresponding meaning that is defined below. Where a word or phrase in this document is **not bolded**, it has the meaning given to it in (in order of priority):

(a) the *Environmental Protection Act 1994*, its regulations or its environmental protection policies;

(b) *Environmental Offsets Act 2014*;

(c) *Regional Planning Interests Act 2014*;

(d) *Waste Reduction and Recycling Act 2011*;

(e) *The Acts Interpretation Act 1954*;

(f) the Macquarie Dictionary (taking account of the context in which the word or phrase is used in this document).

Defined words or phrases in the singular include the plural and vice versa.

Activity, activities means the environmentally relevant activity(s) to which the environmental authority relates. An activity may be undertaken on the whole or a part of a **site**.

Administering authority means the Chief Executive administering the *Environmental Protection Act 1994*.

Annual mass load is calculated as follows:

Annual mass load **total nitrogen** (kg) = yearly sum of daily release volume (ML) x yearly long term **median total nitrogen** concentration (mg/L); and

Annual mass load total phosphorus (kg) = yearly sum of daily release volume (ML) x yearly long term **median** total phosphorus concentration (mg/L).

Note: calculations should be undertaken on a rolling basis based on nutrient sampling.

Annual mass load (offset) means the annual mass load minus a **nutrient offset** approved by the **administering authority.**

Beginning of releases to waters means the date the first approved release of **treated sewage effluent** from the **lagoon** occurs.

Appropriately qualified person means a person or persons who has professional qualifications, training, skills and experience relevant to the environmental authority (EA) requirements and can give authoritative assessment, advice and analysis in relation to the EA requirements using the relevant protocols, standards, methods and/or literature.

BOD_5 means the 5-day biochemical oxygen demand determined using standard tests (e.g. those used by **NATA** laboratories). This test is not inhibited for nitrification, otherwise would be referred to as “carbonaceous” BOD.

Bypass(es) means when the standard treatment processes of the sewage treatment plant, excluding screening, do not occur:

(a) as a result of wet weather and inflows that are in excess of the daily peak design capacity for inflow of the sewage treatment plant; and

(b) the release of untreated, or partially treated, **effluent** from the sewage treatment plant to the environment occurs.

Composite samples, composite sampling means taking one sub sample of equal volume every three hours over 24 hours in a **day** to make a single sample. Note: **composite sampling** includes the use of an automatic sampler as well as a portable sampler.
Commercial place means a place used as a workplace, an office or for business or commercial purposes and includes a place within the curtilage of such a place reasonably used by persons at that place.
Contributing flow paths means the releases to the **lagoon** from the balance tank overflow (**bypasses** from the treatment plant when wastewater exceeds the treatment plants capacity), chlorine contact tank (treated sewage **effluent** from the treatment plant) and recycled water storage tank overflow.
Day means any 24-hour period of a calendar day.
Design Average Dry Weather Flow (DADWF) means the average dry weather flow of the maximum design capacity of the sewage treatment plant.
Effluent means the liquid fraction of treated sewage.
Effluent disposal areas means areas within Lot 83, 84, 86, 255, 256, 257 and 259 on S312432 that are or have been used for disposal of treated sewage **effluent** (where disposal is considered to be the use of a crop to dispose of the **effluent** above the minimum requirements of water for optimum crop growth). The **effluent disposal area** is a temporary **land** release measure to offset nutrient releases to **receiving waters** until a biologically functioning **MOA** has been established.
Effluent manhole 1 means the manhole so depicted in Appendix 2 – monitoring locations.
Effluent manhole 2 means the manhole so depicted in Appendix 2 – monitoring locations.
Environmental complaints means an expression of dissatisfaction, concern or report, whether written or verbal, about the **activity** and/or its impact on the environment.
Irrigation areas means areas where treated sewage **effluent** is used either for any of the following: (a) Construction purposes (including use in earthworks and for dust suppression); and (b) Greening of landscaped areas on Lots 1 and 4 on SP344900 (i.e. the application of minimum requirements of water for optimum crop growth); and (c) Re-use on Lots 1 and 4 on SP344900 where there is no release to **waters**, **land** (other than for greening of landscaped areas in accordance with subsection (b) of this definition), and no public health impacts.
Lagoon means the storage lagoon that receives **effluent** from **contributing flow paths** and stormwater which is detailed in Appendix 1.
Land means land excluding **waters** and the atmosphere.
Long-term 90th percentile means not more than five (5) of the measured values of the quality characteristic are to exceed the stated release limit for any fifty (50) consecutive samples where: (a) the consecutive samples are taken over a one year period; and (b) the consecutive samples are taken at approximately equal periods; and

(c) the time interval between the taking of the each consecutive sample is not less than six days
Long-term 95th percentile means not more than two (2) of the measured values of the quality characteristic are to exceed the stated release limit for any forty (40) consecutive samples where: (a) the consecutive samples are taken over a forty (40) week period; and (b) the consecutive samples are taken at approximately equal periods; and (c) the time interval between the taking of the each consecutive sample is not less than six days
Long-term median means the middle value of data from **monitoring** events undertaken over 52 consecutive weeks, where half the data are smaller and half the data are larger. If the number of samples is even, the median is the arithmetic average of the two middle values.
Limit of reporting means the lowest level of a substance that can be detected by a method.
M1 means the **monitoring** point within the **MOA** and adjacent to the **MOA** outlet, as per *Appendix 1, Site layout ERA 63*
Maximum means that the measured value of the quality characteristic or contaminant must not be greater than the release limit stated.
Measures has the broadest interpretation and includes plant, equipment, physical objects, **monitoring**, procedures, actions, directions and competency.
Minimum means that the measured value of the quality characteristics or contaminant must not be less than the release limit stated.
MOA means the mangrove offset area located on Lot 4 on SP344900and described in Southern Redland Bay WWTP – Mangrove Design and Receiving Environmental Assessments for the Infrastructure Designation Process, Revision 3 (Lendlease Communities (Shoreline) Ltd 11.02.2021).
Monitor, monitored and monitoring means monitoring the impact of an **activity** on the receiving environment and includes analysing, assessing, examining, inspecting, measuring, modelling or reporting any of the following matters— (a) the quantity, quality, characteristics, timing and variability of the release of any contaminant; and (b) the effectiveness of any control measure; and (c) the characteristics of, and impact on, the receiving environment; and (d) the effectiveness of remedial or rehabilitation measures (if applicable to the relevant monitoring requirement).
NATA means National Association of Testing Authorities.
Nutrient offset, expressed as a percentage, means the amount of **total nitrogen** and/or total phosphorus prevented from entering the receiving environment through an **offsite nutrient reduction action,** as a percentage of the amount of **total nitrogen** and/or total phosphorus release to the receiving environment from the **activity**.
Offsite nutrient reduction action means an action taken to counter-balance a point source nutrient release agreed to by the holder of this environmental authority and the **administering authority**, in accordance with the *Point*

Source Water Quality Offsets Policy 2019 or more recent additions or supplements to the document that become available.
Person means an individual and a corporation, as per section 32D of the *Acts Interpretation Act 1954*.
Waters receiving environment monitoring program (WREMP) means a monitoring program designed to **monitor** and assess the potential impacts of controlled and/or uncontrolled releases of contaminants to the environment from the **activity**.
Receiving waters for the purposes of the **WREMP** means: (a) the waters of Logan River; and (b) any surface **waters** or **environmental values** associated with surface **waters** that will potentially be directly affected by an authorised release from the **activity**; and (c) does not include the **lagoon.**
Records include breach notifications, written procedures, analysis results, monitoring reports and monitoring programs required under a condition of this authority.
Release of a contaminant into the environment or **release** means to: (a) deposit, discharge, emit or disturb the contaminant; or (b) cause or allow the contaminant to be deposited, discharged, emitted or disturbed; or (c) fail to prevent the contaminant from being deposited, discharged emitted or disturbed; or (d) allow the contaminant to escape; or (e) fail to prevent the contaminant from escaping.
Saturated means the soil moisture level is greater than the soil field capacity.
Secondary containment system means a system designed, installed and operated to prevent any release of contaminants from the system, or containers within the system, to **land**, groundwater, or surface **waters**.
Sensitive place includes any of the following places: (a) a dwelling, residential allotment, mobile home or caravan park, residential marina or other residential premises; or (b) a motel, hotel or hostel; or (c) a kindergarten, school, university or other educational institution; or (d) a medical centre or hospital; or (e) a protected area under the *Nature Conservation Act 1992*, the *Marine Parks Act 2004* or a World Heritage Area; or (f) a public park or garden; or (g) for noise, a place defined as a sensitive receptor for the purposes of the Environmental Protection (Noise) Policy 2019; or (h) the area within the curtilage of any of the above places.

Short-term median means the middle value of data from monitoring events undertaken over 5 consecutive weeks, where half the data are smaller and half the data are larger. If the number of samples is even, the median is the arithmetic average of the two middle values.
Stage 1 refers to the initial construction stage of the sewage treatment plant, where the maximum treatment capacity of the plant is up to 6.75 ML per day (5 x **DADWF**).
Stage 2 refers to the second construction stage of the sewage treatment plant, where the maximum treatment capacity of the plant is up to 8.1 ML per day (3 x **DADWF**).
The site, site means the following areas of land identified as being approved for the carrying out of the relevant **activity**: Lot 1 on SP344900, Lot 4 on SP344900, Lot 83 on S312432, Lot 84 on S312432, Lot 86 on S312432, Lot 255 on S312432, Lot 256 on S312432, Lot 257 on S312432 and Lot 259 on S312432.
Total Nitrogen TN, Total Nitrogen, TN means the sum of Organic Nitrogen, Ammonia Nitrogen, Nitrite plus Nitrate Nitrogen, expressed as mg/L as Nitrogen. This includes both the inorganic and organic fraction of nitrogen.
Total Phosphorus TP, Total Phosphoros, TP means the sum of the reactive phosphorus, acid-hydrolysable phosphorus and organic phosphorus, as mg/L of Phosphorus. This includes both the inorganic and organic fraction of phosphorus**.**
Trigger values are physicochemical, biological, or other parameter-specific measurement values used to indicate where an environmental value is at risk of environmental harm.
Viable state or viability means able to live and grow.
Waters includes river, stream, lake, lagoon, pond, swamp, wetland, unconfined surface water, unconfined water, natural or artificial watercourse, bed and bank of any waters, dams, non-tidal or tidal waters (including the sea), stormwater channel, stormwater drain, roadside gutter, stormwater run-off, and groundwater and any part thereof.
W1 means the authorised release point to waters, being the outlet of the **lagoon**, as per *Appendix 1, Site layout ERA 63.*

Appendices

Appendix 1, Site layout ERA 63

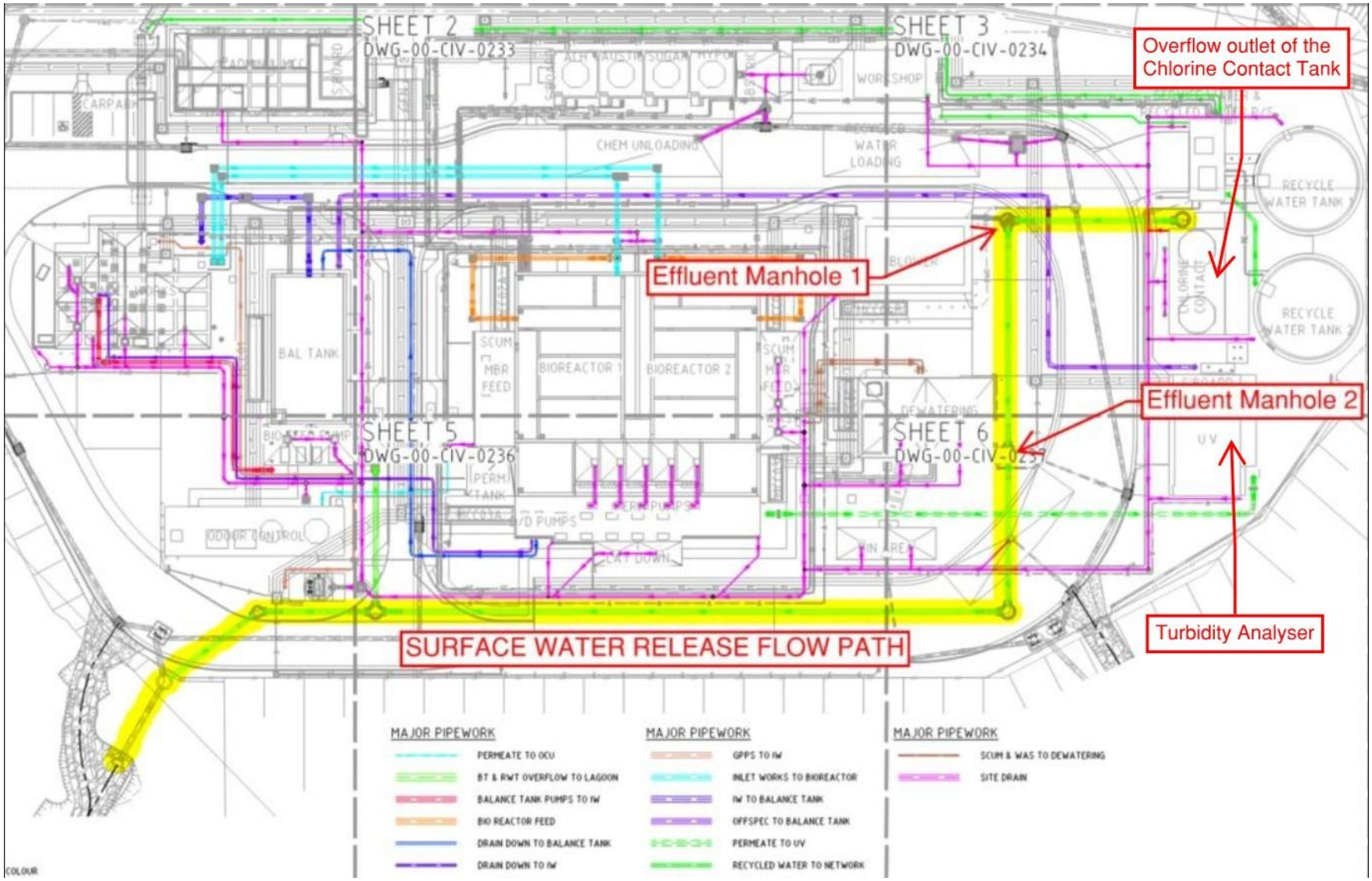


ABN 46 640 294 485

DELIVERING FOR QUEENSLAND

Queensland Government

Appendix 2, Monitoring locations



END OF ENVIRONMENTAL AUTHORITY

Attachments:

1. Concept Mangrove Rehabilitation Plan (Saunders Havill, 26.10.20)
2. Concept WWTP / Storage Lagoon Rehabilitation Plan (Saunders Havill, 10.11.20)
3. Southern Redland Bay WWTP – Mangrove Design and Receiving Environmental Assessments for the Infrastructure Designation Process, Revision 3 (Lendlease Communities (Shoreline) Ltd 11.02.2021).

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT MANGROVE REHABILITATION PLAN

PLAN SET				
SHEET NO.	**TITLE**	**DESCRIPTION**	**ISSUE**	**DATE**
1	9061 E 01 CMRP D	Cover sheet	D	26/10/2020
2	9061 E 02 CMRP D	Background, Framework & Guidelines	D	26/10/2020
3	9061 E 03 CMRP D	Methodology & Preliminary Assessments	D	26/10/2020
4	9061 E 04 CMRP D	Rehabilitation Design – Context	D	26/10/2020
5-10	9061 E 05-10 CMRP D	Rehabilitation Design - Details	D	26/10/2020
11	9061 E 11 CMRP D	Site works / Weed Notes	D	26/10/2020
12	9061 E 12 CMRP D	Pest Management / Site Preparation	D	26/10/2020
13	9061 E 13 CMRP D	Planting Notes	D	26/10/2020
14	9061 E 14 CMRP D	Planting Notes	D	26/10/2020
15	9061 E 15 CMRP D	Planting Notes / Fauna Notes	D	26/10/2020
16	9061 E 16 CMRP D	Planting Species Schedule	D	26/10/2020
17	9061 E 17 CMRP D	Maintenance, Monitoring & Reporting	D	26/10/2020
Appendix A	9061 E AA CMRP D	Reference list / Tidal Glossary	D	26/10/2020
Appendix B	9061 E AB CMRP D	Weed Schedule and Treatment	D	26/10/2020
Appendix C	9061 E AC CMRP D	Marine Plant Schedule	D	26/10/2020
Appendix D	9061 E AD CMRP D	Indicative Maintenance Schedule	D	26/10/2020
Appendix E	9061 E AE CRMP D	Table of performance indicators	D	26/10/2020



INTRODUCTION

This Concept Mangrove Wetland and Salt Marsh Rehabilitation Plan, herein referred to as the 'concept mangrove rehabilitation plan', has been prepared by Saunders Havill Group (SHG) for Lendlease Communities (Australia) Limited (Lendlease) and forms part of the Environmental Assessment Report being submitted to Queensland Treasury in relation to the Southern Redland Bay Wastewater Treatment Project (SRBWTP) proposed at 38 Longland Road, Redland Bay.

Initial investigations into sewer servicing infrastructure for the Shoreline development and broader southern Redland Bay Catchment advised that there were no existing feasible options to service the region's anticipated population of approximately 13,500 equivalent persons, or up to 5,000 dwellings.

Following extensive due diligence investigations, construction of the SRBWTP at the subject site was agreed by all departments to be an ecologically sustainable solution.

This rehabilitation plan relates specifically to the mangrove wetland and salt marsh components of the SRBWTP, which is primarily intended to offset nutrients from the WWTW through nitrogen retention/de-nitrification (with the added benefit of offsetting carbon as a carbon sink), supporting coastal fisheries and wildlife and minimising disturbance to existing threatened communities.

This rehabilitation plan is intended to provide a clear methodology for the propagation and establishment of the mangrove wetland and salt marsh areas, and ongoing maintenance, monitoring and reporting requirements throughout the life of the project.

This rehabilitation plan should be read in conjunction with other environmental assessments and site management plans, including:

- Southern Redland Bay WWTP – Mangrove Design and Receiving Environmental Assessments for the Infrastrucutre Designation Process (Water Technology 2020)
- Culvert Sizing Report (Water Technology 2020)
- Ecological Assessment Report (SHG 2020)
- Vegetation Clearing and Fauna Management Plan (SHG 2020)
- Bushfire Management Plan (LEC 2020)
- Geotechnical Assessment & Acid Soil Management Plan (Douglas Partners 2019)
- Biting Insects Management Plan and consultant's report (FRC Environmental 2019)
- The Recycled Water Master Plan (Stantec 2020)
- Construction Management Plan (Stantec 2020)
- Site-based Management Plan (Stantec 2020)

PREPARED BY:

saunders havill group

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surveying # town planning # urban design # environmental management # landscape architecture

CLIENT:

lendlease

DISCLAIMER:

THESE PLANS HAVE BEEN PREPARED FOR THE EXCLUSIVE USE OF THE CLIENT. SAUNDERS HAVILL GROUP CANNOT ACCEPT REPONSIBILITY FOR ANY USE OF OR RELIANCE UPON THE CONTENTS OF THESE DRAWING BY ANY THIRD PARTY.

CONFIRM ALL DIMENSIONS ON SITE PRIOR TO CONSTRUCTION AND DO NOT SCALE FROM THE DRAWINGS. ALL DIMENSIONS ARE IN MILLIMETRES. ANY DISCREPANCIES SHOULD BE CLARIFIED IN WRITING WITH SAUNDERS HAVILL GROUP PRIOR TO THE COMMENCEMENT OF WORK.

PRIOR TO ANY DEMOLITION, EXCAVATION OR CONSTRUCTION ON SITE, THE RELEVANT AUTHORITY SHOULD BE CONTACTED FOR FURTHER UNDER-GROUND SERVICES AND DETAILD LOCATIONS OF ALL SERVICES.

REFERENCES:

Engineering drawings (KN Group / Stantec 2020)

Layout drawings (SHG 2020)

AMENDMENTS:

Issue	Date	Description	Checked
A	19/06/2020	Preliminary	KG/NC
B	26/10/2020	Amended layout / 3rd Party Review	KG/NC
C	01/09/2020	DAF Updates	KG/NC
D	26/10/2020	DAF / Base Updates	KG/NC

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PROJECT:

38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 2/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF: Cover Sheet

DATE:	23/08/2019	CHECKED:	JB/NC
CLIENT REF:	8868	DRAWN:	MC
DRAWING No.:	8868 E 01 CMRP D		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT MANGROVE REHABILITATION PLAN - NOTES

INTRODUCTION

This Concept Mangrove Wetland and Salt Marsh Rehabilitation Plan, herein referred to as the 'mangrove rehabilitation plan', has been prepared by Saunders Havill Group (SHG) for Lendlease Communities (Australia) Limited (Lendlease) and forms part of the Environmental Assessment Report being submitted to Queensland Treasury in relation to the Southern Redland Bay Wastewater Treatment Project (SRBWTP) proposed at 38 Longland Road, Redland Bay.

Initial investigations into sewer servicing infrastructure for the Shoreline development and broader southern Redland Bay Catchment advised that there were no existing feasible options to service the region's anticipated population of approximately 13,500 equivalent persons, or up to 5,000 dwellings.

Following extensive due diligence investigations, construction of the SRBWTP at the subject site was agreed by all departments to be providing an ecologically sustainable solution.

This rehabilitation plan relates specifically to the mangrove wetland and salt marsh components of the SRBWTP, which is primarily intended to offset nutrients from the WWTP through nitrogen retention/de-nitrification (with the added benefit of offsetting carbon as a carbon sink), supporting coastal fisheries and wildlife and minimising disturbance to existing threatened communities.

This rehabilitation plan is intended to provide a clear methodology for the propagation and establishment of the mangrove wetland and salt marsh areas, and ongoing maintenance, monitoring and reporting requirements throughout the life of the project.

BACKGROUND

Contextually, the subject site is located to the south of Longland Road at Redland Bay, on an outer bend of the Logan River, about 7.5 km upstream from the mouth of the river. The Logan River spans the southern boundary of the site while Serpentine Creek spans the western boundary. The site is partly bounded by Rocky Passage Road with residential property located beyond to the east. Rural properties are located further afield to the west and south-east of the site.

The site is approximately 75 hectares (ha) and extends over four (4) lots within the RCC local government area. Serpentine Creek forms the boundary between the administrative areas of Redland City and Logan City Council areas.

Vegetation

The subject site is mapped as containing remnant Endangered RE 12.11.27 and Least Concern RE 12.1.2 and composite RE12.3.5/12.3.6 (80/20). Mapping of Least Concern RE12.1.2 was confirmed along Serpentine Creek. Mapping of composite Least Concern RE12.3.5/12.3.6 and Endangered 12.11.27 was confirmed along the bank of the Logan River. Mapping of High Value Regrowth for Least Concern RE 12.3.5/12.3.6 and Endangered 12.11.27/12.11.23/12.11.26 (60/30/10) around the existing dwelling in the northern extent was corrected as part of a PMAV. The balance of the site was not surveyed and will not be impacted by the proposal.

The majority of Lot 1 SL3427 is cleared land for grazing with retained areas of vegetation located centrally on the lot. An existing fresh water dam is located across Lot 1 on SL3427, Lot 254 on S31102 and Lot 3 on RP223470 and runs north to south. An area of land is cleared of vegetation adjacent to the dam on Lot 3 RP223470, the balance of land retains vegetation cover. A dwelling is sited at the northern part of Lot 3 on RP223470 with access leading from Longland Road.

Vegetation at the proposed mangrove rehabilitation area is described as follows:

- The majority of the mangrove wetland and saltmarsh area reflects cleared open paddocks. An intermediate area contains tracks and small drainage lines that are under intermittent tidal influence. The vegetation along the tracks and drainage lines contains marine plants, predominantly, *Sporobolus virginicus* (Salt Couch) and *Juncus krausii* (Sea Rush). Portions of the intermediate area not directly along the tracks and drainage lines are dominated with the weed *Baccharis halimifolia* (Groundsel).
- The south-west portion of the site is tidally influence and is dominated by *Sporobolus virginicus* (Salt Couch) with patches of *Tecticornia australasica* (Grey Samphire)—particularly where old crop rills remain. This area is consistent with the definition of the EBPC listed Threatened Ecological Community 'Subtropical and Temperate Coastal Saltmarsh'.
- Three patches of Casuarina glauca (Swamp She-oak) are present within the open paddock area. The largest of which in Lot 1 on SL3427 adjoining Serpentine Creek is considered to be part of the EPBC Act Threatened Ecological Community 'Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community'.
- Riparian vegetation along Serpentine Creek has been cleared as a result of historical land use. Mangrove was the dominant vegetation along the banks of the Logan River and Serpentine Creek. The dominant mangrove species was *Avicennia marina* (Grey Mangrove) with some *Aegiceras coniculatum* (River Mangrove) and *Bruguiera gymnorhiza* (Orange Mangrove).

Soils

The Atlas of Australia soils maps the site as containing Hydrosols (soils that are saturated with water for long periods of time). The Geological Survey of Queensland's 1:100,000 series Brisbane Sheet indicates that the site is located in an area which is underlain predominately by Alluvium typically comprising second river terrace; sand, silt clay and gravel of the Tertiary to Quaternary geological period; and along the eastern boundary of the site by Miscellaneous Unconsolidated Sediments comprising estuarine channels and banks; sandy mud, muddy sand, minor gravel of the Tertiary to Quaternary geological period. The Department of Natural Resources and Mines 1:100,000 series Acid Sulphate Soils map for Tweed Heads to Redcliffe indicates that the site is "land where ASS occurs within 5 m of the surface".

The subsurface conditions encountered during geotechnical assessments generally comprised filling over alluvial clay soils, which is in general agreement with published geological information. Subsurface conditions are described in further detail as upper clayey sand topsoil to depths of between 0.1 m and 0.3m underlain by alluvial soils. The alluvial soils generally comprised high plasticity, estimated soft to firm sandy clay to depths between 0.7 m and 1.2 m and then estimated loose clayey sand to the termination depth of 2 m.

Free groundwater was observed at all sample sites between 0.2 m and 1 m depth. Groundwater depths are affected by climatic conditions and soil permeability, and tidal conditions at this site, and will therefore vary with time.

Conceptual design

The design intent for the SRBWTP is to treat incoming sewage and to maximise the reuse of recycled water. The SRBWTP conceptual design comprises a number of components:

- New staged pipelines to connect the waste water treatment plant (WWTP) to the reticulated sewer network
- The WWTP - to remove nutrients and pathogens (at least 99.9% of pathogens to be removed prior to discharge to wetland)
- An additional recycled water main to transfer water back to the southern Redland Bay area for re-use
- A new freshwater storage lagoon to store water before being gravity fed to the mangrove forest.
- A new mangrove forest – whereby an existing tidal inlet from the Logan River will be connected to the mangrove forest to allow water to be flushed in a one-way direction through the mangrove forest, where it will mix with flows from the WWTP before being discharged into Serpentine Creek via an outlet at the western end of the site.
- Salt Marsh – Located in the outer fringes of the proposed mangrove forest
- Mangrove forest and salt marsh areas are 9.854ha combined
- Deeper central flow channel – Designed to meander through the mangrove to provide maximum effluent engagement with mangroves and salt marsh areas within the site.
- Ancillary structures including a sediment forebay on the inlet to capture excess sediment and maintenance access for the sediment forebay

Construction phases

Project construction of the plant will be split into four (4) phases, with each stage providing progressively increased capacity for additional residents in line with population growth and establishment of mangrove and saltmarsh areas.

A temporary disposal / irrigation area to the north of the site is proposed during early stages of mangrove establishment. Initial inflows to the WWTP are anticipated to be relatively low due to the rate of new dwellings being constructed. The mangrove wetland will become operational once the mangroves are of sufficient size to effectively remove nutrients from the water.

Phase 1: Construction

- Year 1 – mangrove wetland constructed and planting occurs to assist establishment during construction of the WWTP.

Phase 2: No Discharge to Mangrove Wetland

- Year 2 - Wastewater transport ceases and Stage 1A of the WWTP produces recycled water which is used to supply water for construction, landscaping and irrigation. There is no excess recycled water and no discharge to mangrove wetlands.

Phase 3: Increasing Discharge to Mangrove Wetland

- Years 3 & 4 – The recycled water storage lagoon is established. Additional recycled water is used for temporary irrigation. A small discharge (in extreme wet weather) is proposed through the freshwater storage lagoon to the mangrove wetland.
- Year 5 & 6 - Discharge is increased to the mangrove wetlands, with levels of discharged monitored adapted and depending on success temporary irrigation may be ceased. Stage 1B of the WWTP will be constructed.

Phase 4: Ultimate Scheme

- Year 7 – Recycled water discharge is managed between the mangrove wetland and irrigation of sports parks and ovals.

In light of current / projected rates of development in the catchment—delivery of the infrastructure will be required by December 2021 with an additional 2 to 5-year timeframe before the mangrove wetland can be used as an offset.

REHABILITATION – FRAMEWORK AND GUIDELINES

Specific guidelines for the rehabilitation of mangrove and saltmarsh communities have been developed by the Queensland Government to direct planning, design and management efforts towards best restoration practices for fish habitat areas.

The Queensland Government's 'Fish Habitat Guidelines FHG 002: Restoration of Fish Habitats' provide guidance on the restoration (i.e. returning the site to an agreed pre-existing condition) of degraded marine plant sites in Queensland. Principles of the guideline are also relevant to the rehabilitation of new marine plant sites (i.e. returning a site to a state where natural succession can continue the recovery process and allow fisheries values of the site to be returned). The principles of the Guidelines are as follows:

- assessing the site before any works to identify causes of degradation, and to assess ecological feasibility
- establishing goals and criteria for success
- implementing the works
- monitoring the site after works i.e. survival and growth of plants
- ongoing management i.e. weed treatment and infill planting, and
- feedback to future restoration plans

According to the Guidelines, a revegetation strategy should address:

- preparation of the site so it has the appropriate profile, hydrology, and soil conditions
- selection of species, including consideration of:
    - site conditions (e.g. salinity, soil characteristics, tidal profile, inundation frequency, water quality and hydrology)
    - available stock of local provenance
    - propagation method
    - legal or other restrictions
    - propagation and stock management techniques, including:
        - the quantity required
        - the source of the material
        - timing of propagule collection
        - the need for nursery development
        - method of planting, and
        - timing of planting – to ensure plants are not washed away by high tides or floods
    - receive enough freshwater, and
    - planted in an appropriate growing season.

The Ecological Mangrove Rehabilitation / Restoration (EMR) Protocol is a 6-step process that has been used to guide several successful mangrove projects world-wide, and has been adopted in the planning and design of this project to ensure that the procedures and methodologies adopted are technically sound and tailored to the needs of this project. The 6 steps of the EMP are as follows:

1. Understand the autecology (individual species ecology) of the mangrove species at the site, the patterns of reproduction, propagule distribution, and successful seedling establishment.
2. Understand the normal hydrologic patterns that control the distribution and successful establishment and growth of targeted mangrove species.
3. Assess the modifications of the previous mangrove environment that currently prevent natural secondary succession.
4. Select appropriate mangrove restoration sites through application of Steps 1–3. These steps increase the likelihood of success in restoring a sustainable mangrove wetland ecosystem and are cost-effective given the available funds and manpower to implement projects, including adequate monitoring to assess quantitative goals established prior to restoration. This step includes resolving landowner - ship/use issues necessary for ensuring long-term access to and conservation of the site.
5. Design the restoration program at appropriate sites selected in Step 4 to initially restore the appropriate hydrology and utilize natural mangrove propagule recruitment for plant establishment
6. Only utilize actual planting of propagules, collected seedlings, or cultivated seedlings after determining through steps 1–5 that natural recruitment will not provide the quantity of successfully established seedlings, rate of stabilization, or rate of growth of saplings established as quantitative goals for the restoration project.

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REFERENCES:
Refer to Appendices for list of document references

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C	01/09/2020	DAF Updates	KG/NC
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PROJECT:
38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 2/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF:
Background, introduction

DATE:	23/08/2019	CHECKED:	JB/NC
CLIENT REF:	8868	DRAWN:	MC

DRAWING No.: 8868 E 02 CMRP D

CONCEPT REHABILITATION PLAN - NOTES

Function refers to the natural and self-sustaining processes occurring within the site including regeneration capacity, succession and cycling of nutrients. Activities required to achieve these objectives may include controlling environmental weeds, re-establishment of wildlife corridors and or stabilisation of creek banks.

As restoration work progresses on a site, ongoing changes to the structure and diversity of the vegetation will become apparent. These changes tend to occur in a cyclical manner, with the initial disturbance to the vegetation (either natural or man-made) being the trigger for changes. It is important to recognize that the vegetation will have to pass through a variety of stages of succession first, often over a period of years.

While disturbance as part of restoration works often has a negative connotation, it can also be useful in restoration. Regeneration of native plant species is stimulated by mimicking natural disturbances. The techniques used will depend on the individual species and vegetation community, as they have evolved to respond to disturbances in different ways. Some example techniques are:

- Control of competing vegetation, especially environmental weeds;
- Controlled burns or burn piles in vegetation communities adapted to fire;
- Soil disturbances such as ripping or raking; and or
- Alterations to hydrology in wetlands to reinstate natural movement.

The SEQERF also highlights that consistent follow up is critical successful ecological restoration. This ensures that beneficial, permanent changes can occur within the vegetation community benefiting both fauna and flora. Ongoing site monitoring may also be required to confirm these changes are occurring.

Ecological restoration is a complicated and evolving field. It requires careful consideration for all ecosystem aspects to try and minimise any unexpected interactions, although is generally accepted that not all can be fully known about each complex ecosystem. Given this, it is necessary to remain flexible throughout this process to adapt to site and natural changes.

REHABILITATION - APPROACHES

ECOLOGICAL RESTORATION APPROACHES	
NATURAL REGENERATION	
Applies:	To relatively large, intact and weed-free areas of native vegetation. Where native plants are healthy and capable of regenerating without human intervention. When native plant seed is stored in the soil or will be able to reach the site from nearby natural areas, by birds or other animals, wind or water. Where the plant community has a high potential for recovery after any short-live disturbance such as a fire or cyclonic winds. When preventative action is all that is required to avert on-going disturbances e.g. erection of fencing to prevent instruction by cattle.
Role of planting:	Planting in such areas can work against the aims of restoration by interfering with natural regeneration.
Goal	The re-establishing plant community will be similar in structure, composition and diversity to the original vegetation.
ASSISTED NATURAL REGENERATION	
Applies:	To natural areas where the native plant community is largely healthy and functioning. When native plant seed is still stored in the soil or will be able to reach the site from nearby natural areas, by birds or other animals, wind or water. Where the natural regeneration processes (seedling germination, root suckering, etc.) are being inhibited by external factors, such as weed invasion, soil compaction, cattle grazing, mechanical slashing, etc.
	When the main management issue is weed infestation and/or current land use practices.
	When limited human intervention, such as weed control, minor soil amelioration, erection of fencing, cessation of slashing, etc. will be enough to trigger the recovery processes through natural regeneration.
Role of planting:	Planting in such areas can work against the aims of restoration by interfering with natural regeneration except where species cannot return to site without direct intervention.
Goal	The re-establishing plant community will be substantially similar in structure, composition and diversity to the original vegetation.
RECONSTRUCTION	
Applies:	Where the site is highly degraded or altered. When the degree of disturbance has been so great and long-standing that the pre-existing native plant community cannot recover by natural means. To sites such as areas of fill, sites affected by stormwater flow, areas that have been drastically cleared, even though there may be a few remaining native trees or shrubs. When a greater degree of human intervention is required, such as weed control, cessation of grazing and/or slashing, amelioration of soil conditions such as importation of soils, drainage works or re-contouring.
Role of planting:	Importation of native species to the area is required, either through planting or direct seeding (in some situations). natural regeneration and recruitment is insufficient to initially re-establish the original vegetation. Depending on the prevailing circumstances, the planting of a broad diversity of species from the target ecosystem may be unnecessary and the use of pioneers may be sufficient to re-establish ecological processes.
Goal	The re-establishing planted community should be similar to the original vegetation in structure, composition and diversity.
FABRICATION (TYPE CONVERSION)	
Applies:	Where site conditions have been irreversibly changed. When it is not possible to restore the original native plant community. Where a better-adapted local plant community can be planted that will function within the changed conditions. In situations such as the construction of a wetland plant community to mitigate increased urban storm-water run-off.
Role of planting:	Revegetation (planting) is the major component in a fabrication program.
Goal	The re-establishing planted community should be similar to a naturally occurring plant community of the same type (e.g. a constructed freshwater storage lagoon should resemble a natural system in terms of structure, composition and diversity).

Note: Table adapted from City of Gold Coast's 'Guideline for the preparation of a Rehabilitation Plan'

While natural restoration at the subject site would cost significantly less to establish, and is the preferred position in the Guidelines—this process can be slow, particularly where, as at this site, tidal inundation may be restricted and there may not be an abundant source of local propagules. The Guidelines suggest it may be appropriate to revegetate over three years, with any natural revegetation of the site in the first years, decreasing the amount of assisted vegetation required. Active vegetation has also been recommended at the subject site to minimise the time required to attain a functional ecosystem that can be used to offset nutrients, and to assist in preventing erosion of the newly profiled sediment.

In light of these recommendations—fabrication, reconstruction and assisted natural regeneration approaches will be required to create a functional mangrove wetland / saltmarsh at the subject site.

REHABILITATION - METHODOLOGY

Detailed assessment of site conditions prior to commencement of documentation is essential. As part of most rehabilitation scopes, it is worth considering an appropriate methodology for both compiling documentation and site works. This can be broken down into the following items:

- Site assessment
- Rehabilitation design documentation
- Site works
- Maintenance, monitoring and reporting

METHODOLOGY – PRELIMINARY ASSESSMENTS

Many previous mangrove rehabilitation projects have been carried out without adequate site assessments, or subsequent evaluation of the success of planting at the ecosystem level, which has led to misconceptions about the efficacy of similar schemes. In cases where adequate research has been undertaken, and the basic principles of ecological restoration and engineering adopted—the success of such projects has been visibly improved.

Detailed site assessment prior to commencement of documentation is required to inform conceptual design and site-specific rehabilitation methodology.

Prior to the commencement of site establishment works the following material should be compiled consistent with the SEQERF site assessment process checklist to enable monitoring and reporting to be completed:

- Describe the history and background of the site
- Describe the soil, drainage, topography and aspect
- Describe the native vegetation and weeds on site and along site boundaries
- Describe the vegetation dispersal and structure
- Describe the fauna use onsite
- Describe estimated native regeneration response and planting strategy.
- The responses to the above checklist will provide the basis of the proposed restoration approach for each treatment area within this plan.

As part of the development application and due diligence reporting, terrestrial flora and fauna surveys were undertaken by SHG, aquatic surveys were undertaken by FRC Environmental, geotechnical assessments were undertaken by Douglas Partners and hydraulic modelling / hydrological assessments were undertaken by Water Technology. Furthermore, the above assessments were peer reviewed by individuals and academics who have demonstrated expertise in the various aspects of mangrove wetland / saltmarsh rehabilitation.

Wetland location

Targeted flora and fauna surveys focussing on threatened species and ecological communities were used to inform the location of the mangrove wetland and salt marsh outside of existing, healthy marine plant areas.

Wetland elevations

Designing a system that features appropriate soil elevations and hydrology, are the two key requirements for the establishment of mangroves. Assessing the existing hydrology of natural extant mangrove ecosystems surrounding the proposed wetland site, and applying this knowledge to the new wetland is important for achieving a successful and cost-effective project. Previous research has widely documented the general principle that mangrove wetlands worldwide exist largely in a raised and sloped platform above mean sea level that is inundated for approximately 30% or less of the time by tidal waters.

The mangrove and salt marsh area elevations adopted the site were informed using the vertical distribution (with respect to tide) of mangrove and saltmarsh habitats within the adjacent Logan Estuary. Nearby mangroves colonise intertidal areas from Mean Water Level (MWL) up to Mean High Water Spring Level (MHWSL), with some mangroves located at elevations of up to 1.5m AHD (Refer to *Appendix 1* for glossary of tidal terms). During high spring tides, nearby areas colonised by salt couch are temporarily inundated.

Water levels within the site are influenced by water levels in the adjacent Estuary, and the dimension and elevation of the culverts at the inlet and outlet locations. When suitably sized cell culverts are installed at 0m AHD, the MWL is approximately 0.5m AHD and the MHWSL is approximately 1.0m AHD. These elevations coincide with the lower and (nearly) upper boundaries of the excavated intertidal area—maximising the area suitable for mangrove colonisation.

Early modelling also factored in sea level rise—which is expected to be approximately 0.8m by 2100. Sea level rise will result in increased frequency of inundation and tidal levels. This will impact on dredging frequency requirements in the sediment basin and on the plants themselves. If sea level rise occurs gradually, it is expected that the plants can accommodate the change and move with the tidal levels. This means that the mangroves might die off in the lower levels that are being inundated more often with sea level rise and start establishing in areas of slightly higher water levels.

The sediment forebay is designed to reduce sediment delivery during major tidal/flood events, however it has been suggested that accumulated sediments may be disposed of onsite periodically—allowing mangroves to persist as sea levels rise. It is important to remember that mangrove health is strongly influenced by sedimentation, and as such, requires careful management.

Mangrove health is also influenced by relative inputs of freshwater and saltwater into the wetland. Freshwater inflows from the WWTP will cause a slight decrease in salinity levels, however the change is not expected to be detrimental to the growth and propagation of mangroves, even at ultimate discharge levels (Refer to Mangrove Design and Receiving Environmental Assessments Report by Water Technology 2020). Positioning of mangrove species according to the salt tolerances will also assist plant survival i.e. *Avicennia marina* (Grey Mangrove) is tolerant to a range of salt levels whereas *Aegiceras corniculatum* (River Mangrove) has a low tolerance.

Wetland size and configuration

Establishing a freshwater storage lagoon in conjunction with the mangrove wetland, maximising the travel time of effluent through the mangrove wetland and establishing a salt marsh area around the periphery of the mangroves were also recommended for optimal nutrient removal efficiency.

Rates of incoming nutrients and nutrient uptake were used to determine the respective area of mangroves and saltmarsh required to remove nutrient loads. While thresholds for maximum nitrogen loading were investigated to ensure that conditions within the mangrove environment did not become anoxic, therefore reducing the efficacy of the system.

The residual effluent load from the WWTP after passage through the freshwater storage lagoon was calculated—which was subsequently the minimum nitrogen removal rate required by the mangroves. A safety factor of 2.5-3 was then added as a precautionary measure to ensure that the receiving environment was protected and where possible, enhanced. In light of these calculations, a total area of 9.854 has been dedicated for the mangrove wetland and salt marsh area.

Similarly, estimated levels of suspended sediments from tidal inflows and tidal prism were also used to determine the size of the sediment pit required.

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REDLAND BAY
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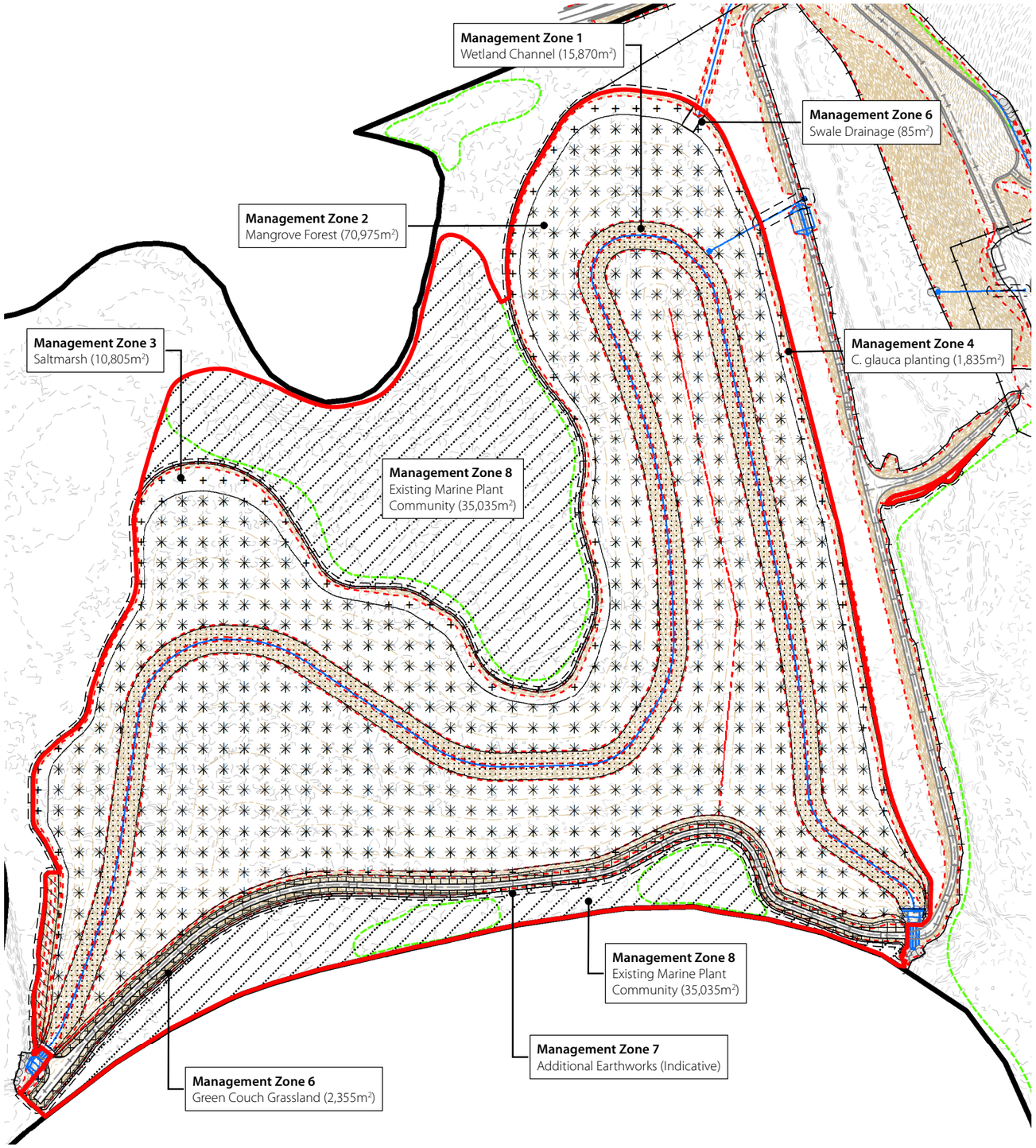
environmental management

PLAN OF:
Background, introduction and habitat establishment

DATE:	26/10/2020	CHECKED:	JB/NC
CLIENT REF:	8868	DRAWN:	MC
DRAWING No.:	8868 E 03 CMRP D		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - MANAGEMENT ZONES



METHODOLOGY – REHABILITATION DESIGN

In accordance with the SEQERF, the rehabilitation design comprising distinct management zones, provides assessment managers, clients and contractors a clear methodology to assist creation of the new mangrove wetland / saltmarsh. The management zones are described in detail below. This zoning has been informed by site assessments, preliminary advice from other consultants and individuals, the Queensland Government's Fish Habitat Guidelines and SEQERF, EMR Protocol and previous rehabilitation project experience. Refer to Rehabilitation notes for additional details, plant species and densities.

Management Zone 1: Wetland channel (Fabrication – No Planting)

Zone to be elevated at varying depths below Zone 2 (RL0.68) to facilitate water flow from inlet and WWTP, through rehabilitation area to outlet. Area to be finalised by civil contractor appropriately prior to rehabilitation works, including, but not limited to: cultivation and scarification to media, installation of final media profile to approved levels / depths, and conducting all tests (flow, conductivity etc.) as required by assessment manager.

Weed management to entire zone to remove any self-seeding weed species prior to planting. Appropriate (sensitive) weed management methodology within this zone to minimise harm to the broader estuarine environment (refer to *Sheet 11* and *Appendix B* for recommended approaches). Ongoing weed management during maintenance period to reinforce primary weed removal.

Erosion-control measures / protective devices to be installed as required following finalisation of civil works and review of site / soil conditions by project manager and rehabilitation works supervisor. Potential measures to be utilised include natural fibre matting to stabilise / capture sediments in the low-flow channel. All measures to be installed as per Manufacturer's recommendations and to meet Department of Agriculture and Fisheries (DAF) requirements for fish passage. Sediment removal to occur annually throughout maintenance period (or as required) using low-impact measures.

Management Zone 2: Mangrove Wetland (Fabrication)

Zone to be elevated at varying depths between the wetland channel (RL0.5) and saltmarsh zone (RL1.0), providing for inundation of mangrove wetland approximately 25% of the time. Area to be finalised by civil contractor appropriately prior to rehabilitation works as per Zone 1. Soil conditioning i.e. addition of organic matter, to be undertaken as required. Primary and follow-up weed management to entire zone as per Zone 1.

Erosion-control measures / protective devices to be installed as required following finalisation of civil works and review of site / soil conditions / planting & propagation method by project manager and rehabilitation works supervisor. Potential measures to be utilised on site include natural fibre matting and staggered coir logs to capture sediments and to prevent damage to plants by herbivores / tidal action (refer diagram on *Sheet 12*). All measures to be installed as per manufacturer's recommendations and DAF requirements for fish passage.

Mangrove seedlings / tubestock / propagules / sods / divots to be installed into muddy substrate during low tide at min. density of 1 plant per 1.5 m². Where densities cannot be achieved at primary planting—infill planting to occur at appropriate times in first and second year until min. plant densities are achieved. Mangrove species to be planted according to preferred intertidal and estuarine position (refer planting notes and *Appendix C*).

Management Zone 3: Saltmarsh / Salt Couch Grassland (Fabrication)

Zone to be elevated at varying depths above upper mangrove limit (RL1.0), allowing for less frequent, low-energy tidal inundation. Area to be finalised by civil contractor appropriately prior to rehabilitation works as per Zone 1. Soil conditioning i.e. addition of organic matter, to be undertaken as required. Primary and follow-up weed management to entire zone as per Zone 1.

Erosion-control measures / protective devices to be installed as per Zone 2.

Saltmarsh seedlings / tubestock / propagules / sods to be installed throughout zone at a minimum density of approximately 1 plant per 1 m². Saltmarsh species to be planted according to preferred intertidal and estuarine position (refer to planting notes and *Appendix C*).

Management Zone 4: *Casuarina glauca* Forest (Reconstruction)

Zone to be elevated at varying depths above upper saltmarsh limit (RL1.5), allowing for infrequent, low-energy tidal inundation. Area to be finalised by civil contractor appropriately prior to rehabilitation works as per Management Zone 1. Soil conditioning i.e. addition of organic matter, to be undertaken as required. Primary and follow-up weed management to entire zone as per Zone 1.

Erosion-control measures / protective devices to be installed as per Zone 2.

Casuarina glauca tubestock to be installed throughout zone at a minimum density of approximately 1 plant per 4 m². Sporobolus virginicus (Salt Couch) ground layer to be installed at 1 plant per 1m².

Management Zone 5: Green Couch Grassland (Fabrication)

Zone to form approximately a 2-metre buffer either side of service access track, inlet and outlet. To be elevated at varying depths above *Casuarina glauca* Forest (>approx. RL1.7). Area to be finalised by civil contractor appropriately prior to rehabilitation works as per Zone 1. Soil conditioning i.e. addition of organic matter, to be undertaken as required. Primary and follow-up weed management to entire zone as per Zone 1.

Native Green Couch turf to be installed throughout zone.

Management Zone 6: Swale drain (Fabrication)

Area to be finalised by civil contractor appropriately prior to rehabilitation works as per Zone 1. Soil conditioning i.e. addition of organic matter, to be undertaken as required. Primary and follow-up weed management to entire zone as per Zone 1.

Highly durable natural fibre matting to be installed throughout zone with additional erosion-control measures i.e. coir logs to be installed as required. All measures to be installed as per Manufacturer's recommendations and DAF requirements for fish passage.

Tubestock planting of groundcovers at rate of 4 per 1m² and to comprise of a mixture of salt-tolerant species. All species to be local provenance from mapped Pre-Clear Regional Ecosystem (RE) over site.

Management Zone 7: Additional Earthworks Zone (Reconstruction)

Areas disturbed during construction that are external to outer batters to be finalised by civil contractor appropriately prior to rehabilitation works as per Zone 1. Soil conditioning i.e. addition of organic matter, to be undertaken as required. Primary and follow-up weed management as per Zone 1.

Zone to be revegetated in accordance with the appropriate zone above according to elevation and where present existing vegetation i.e Area disturbed that is approx. 1.5m ASL to be revegetated in accordance with Management Zone 4.

Management Zone 8: Existing *Casuarina glauca* TEC & surrounding marine plant communities (Assisted Natural Regeneration)

Existing native trees, shrubs and groundcovers to be protected and retained. Weed management to entire zone in accordance with SEQERF to encourage natural regeneration by reducing competition. Primary and follow-up weed management to entire zone as per Zone 1.

Any bare denuded areas to be appropriately cultivated, topsoiled and appropriate protective measures installed as required. All measures to be installed to manufacturer's recommendations.

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Engineering (KN Group / Stantec 2020)

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PROJECT:

38 LONGLAND ROAD
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environmental management

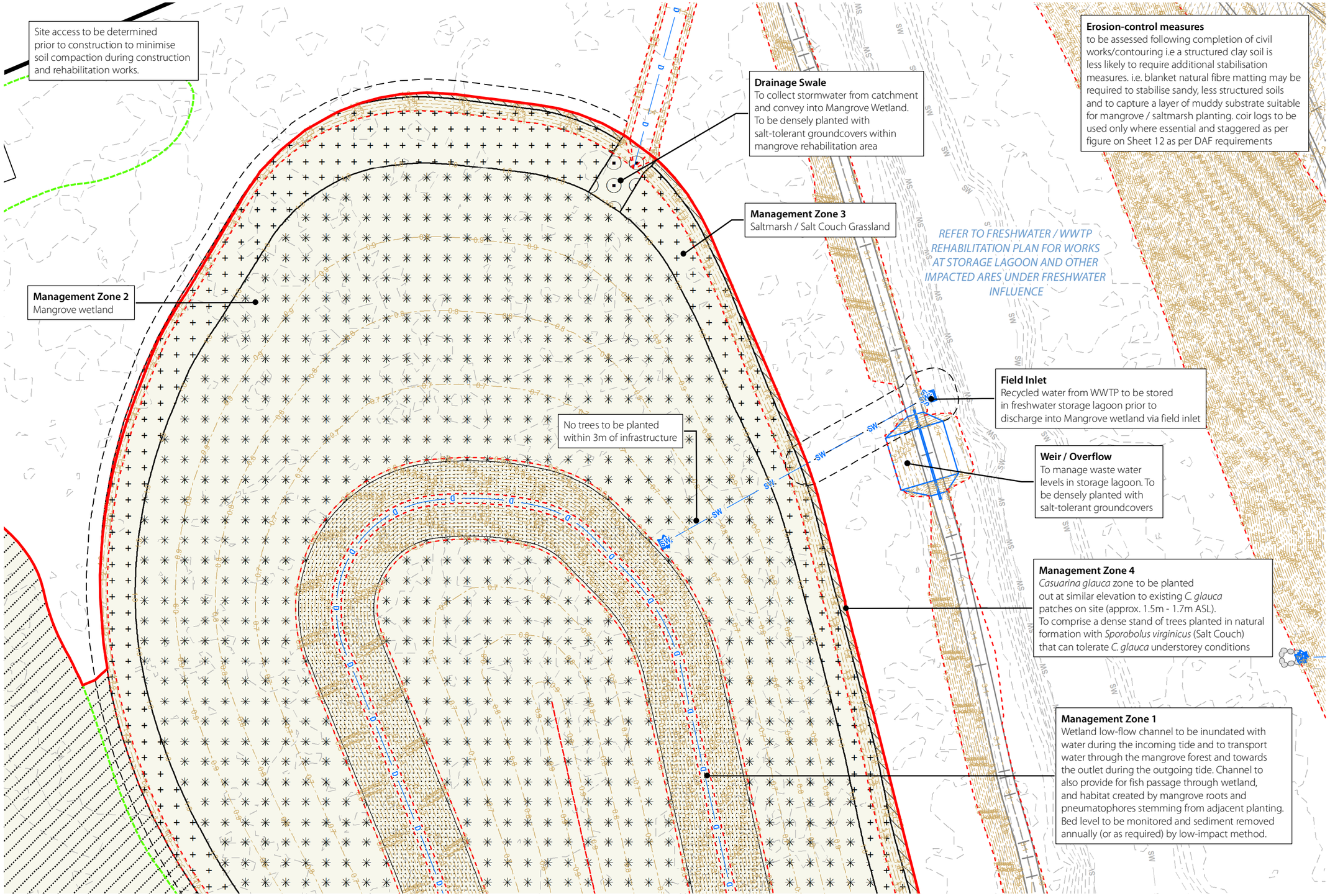
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Management Zones

DATE:	26/10/2020	CHECKED:	JB/NC
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DRAWING No.:	8868 E 04 CMRP D		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - DETAIL SHEET 05



Legend

- Zone 1 - Channel
- Zone 2 - Mangrove
- Zone 3 - Saltmarsh / Salt Couch
- Zone 4 - *C. glauca* planting
- Zone 5 - Green Couch
- Zone 6 - Swale drain
- Zone 7 - Additional Earthworks
- Zone 8 - Existing *C. glauca*
- Earthworks extent
- Survey / DCDB
- Subject site
- Rehabilitation boundary
- Batter
- Design contour
- Existing contour
- Waste Water Treatment Plant
- Rock wall
- Road / pathway
- Fence
- S Services - sewer
- W Services - water
- D Services - drain
- SW Services - stormwater
- Retained vegetation

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Layout drawings (SHG 2020)

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PROJECT:

38 LONGLAND ROAD
REDLAND BAY
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environmental management

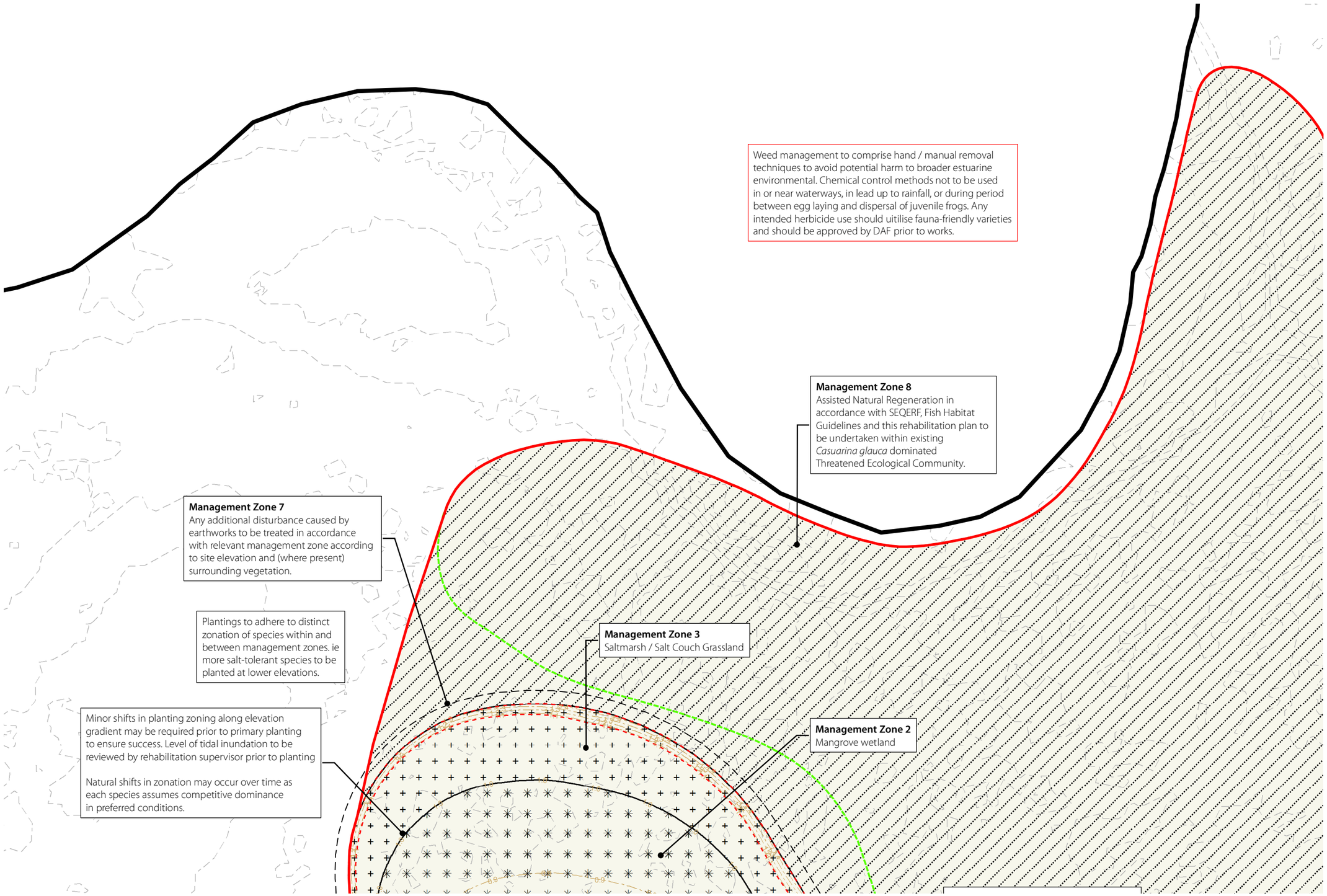
PLAN OF:

Management Zones

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DRAWING No.:	8868 E 05 CRMP B		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - DETAIL SHEET 06



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38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 2/RP223470
1/SL3427, 254/S31102)

environmental management

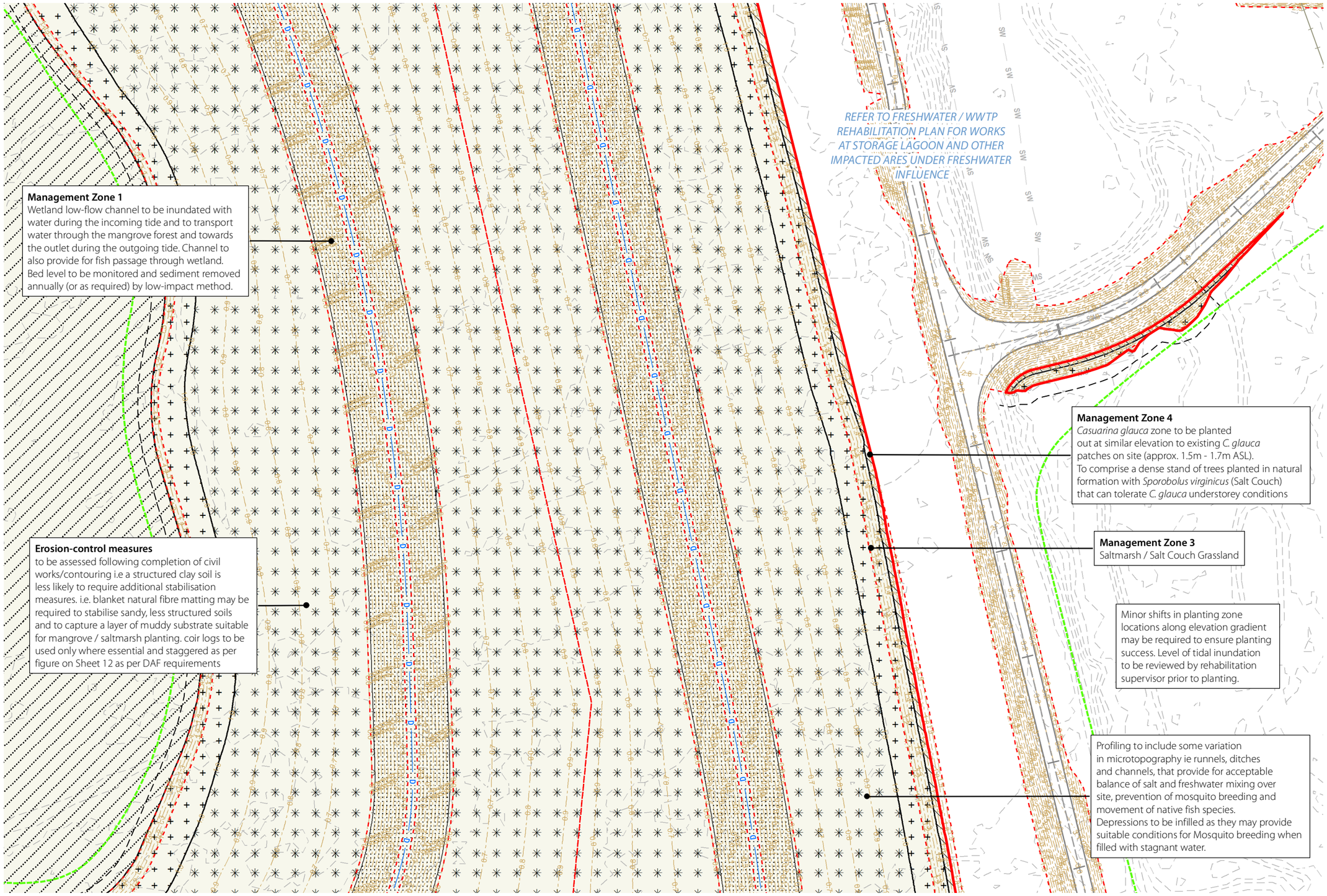
PLAN OF:

Management Zones

DATE:	26/10/2020	CHECKED:	JB/NC
CLIENT REF:	8868	DRAWN:	MC
DRAWING No.:	8868 E 06 CRMP B		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - DETAIL SHEET 07



Legend

- Zone 1 - Channel
- Zone 2 - Mangrove
- Zone 3 - Saltmarsh / Salt Couch
- Zone 4 - *C. glauca* planting
- Zone 5 - Green Couch
- Zone 6 - Swale drain
- Zone 7 - Additional Earthworks
- Zone 8 - Existing *C. glauca*
- Earthworks extent
- Survey / DCDB
- Subject site
- Rehabilitation boundary
- Batter
- Design contour
- Existing contour
- Waste Water Treatment Plant
- Rock wall
- Road / pathway
- Fence
- S — Services - sewer
- W — Services - water
- D — Services - drain
- SW — Services - stormwater
- Retained vegetation

PREPARED BY:

saunders havill group
surveying ▪ town planning ▪ urban design ▪ environmental management ▪ landscape architecture

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PROJECT:

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REDLAND BAY
(2/RP223470, 2/RP223470
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environmental management

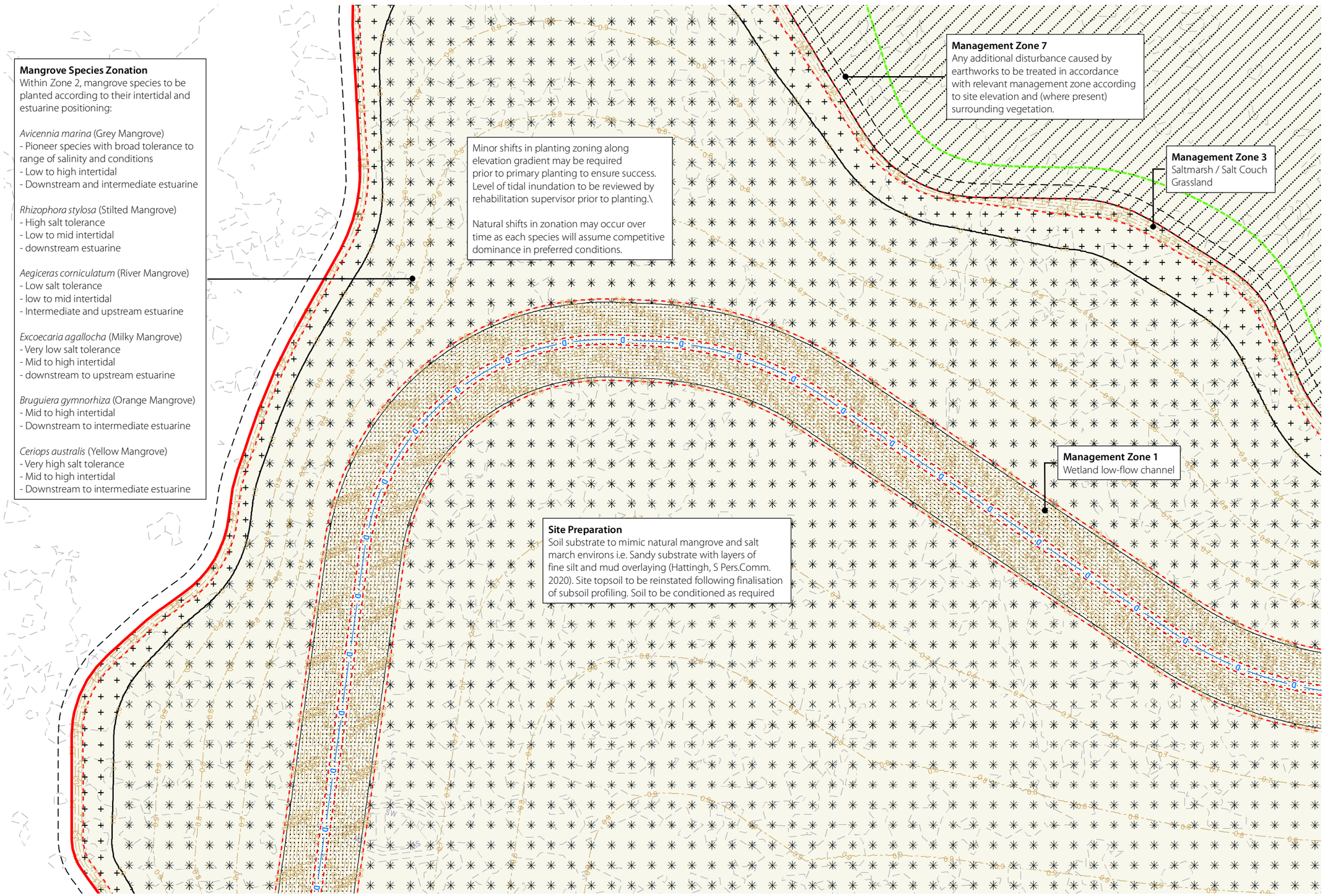
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DRAWING No.:	8868 E 07 CRMP B		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - DETAIL SHEET 08



Legend

- Zone 1 - Channel
- Zone 2 - Mangrove
- Zone 3 - Saltmarsh / Salt Couch
- Zone 4 - *C. glauca* planting
- Zone 5 - Green Couch
- Zone 6 - Swale drain
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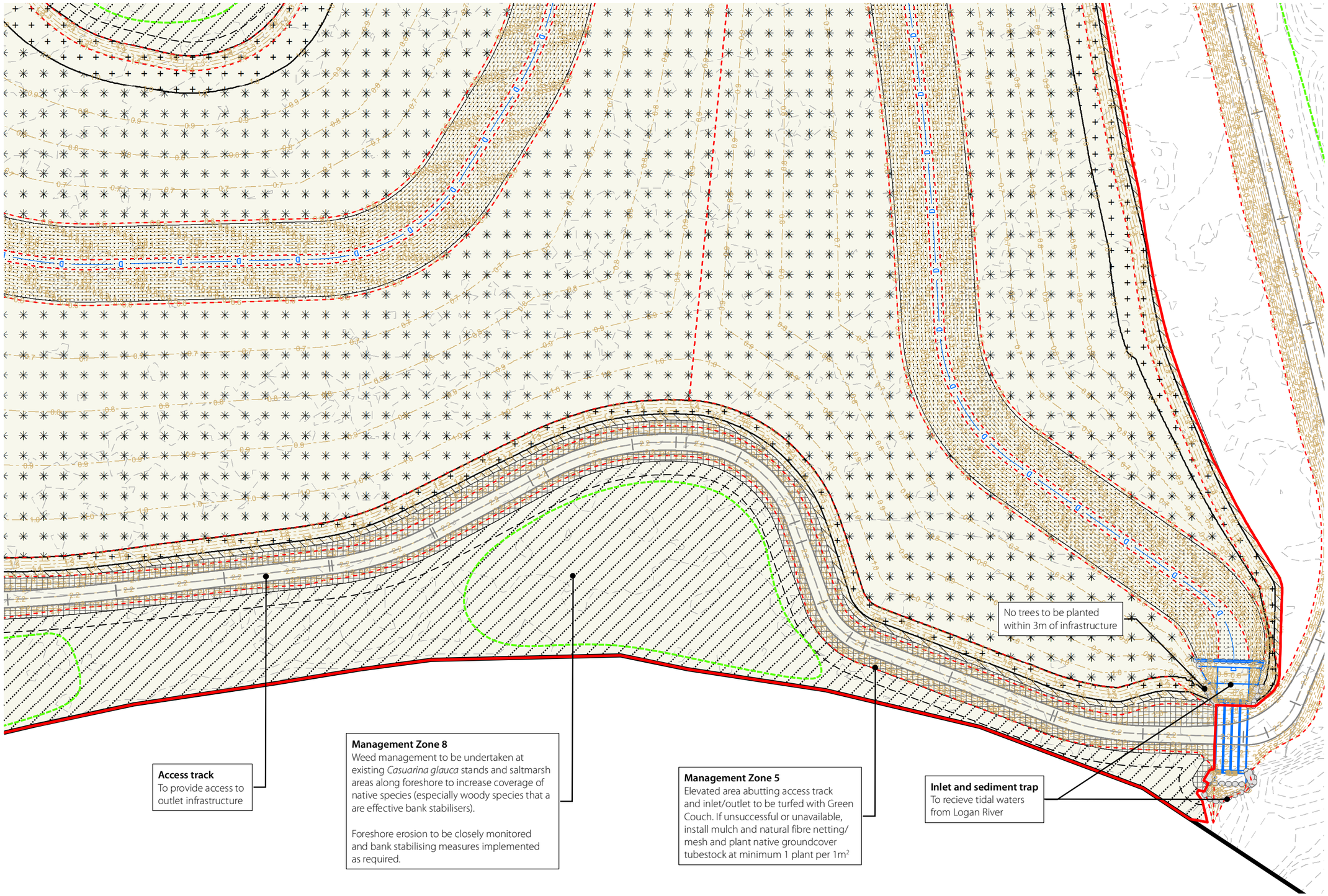
environmental management

PLAN OF: Management Zones

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DRAWING No.:	8868 E 08 CRMP B		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - DETAIL SHEET 09



Access track
To provide access to outlet infrastructure

Management Zone 8
Weed management to be undertaken at existing *Casuarina glauca* stands and saltmarsh areas along foreshore to increase coverage of native species (especially woody species that a are effective bank stabilisers).

Foreshore erosion to be closely monitored and bank stabilising measures implemented as required.

Management Zone 5
Elevated area abutting access track and inlet/outlet to be turfed with Green Couch. If unsuccessful or unavailable, install mulch and natural fibre netting/ mesh and plant native groundcover tubestock at minimum 1 plant per $1m^2$

Inlet and sediment trap
To recieve tidal waters from Logan River

Legend

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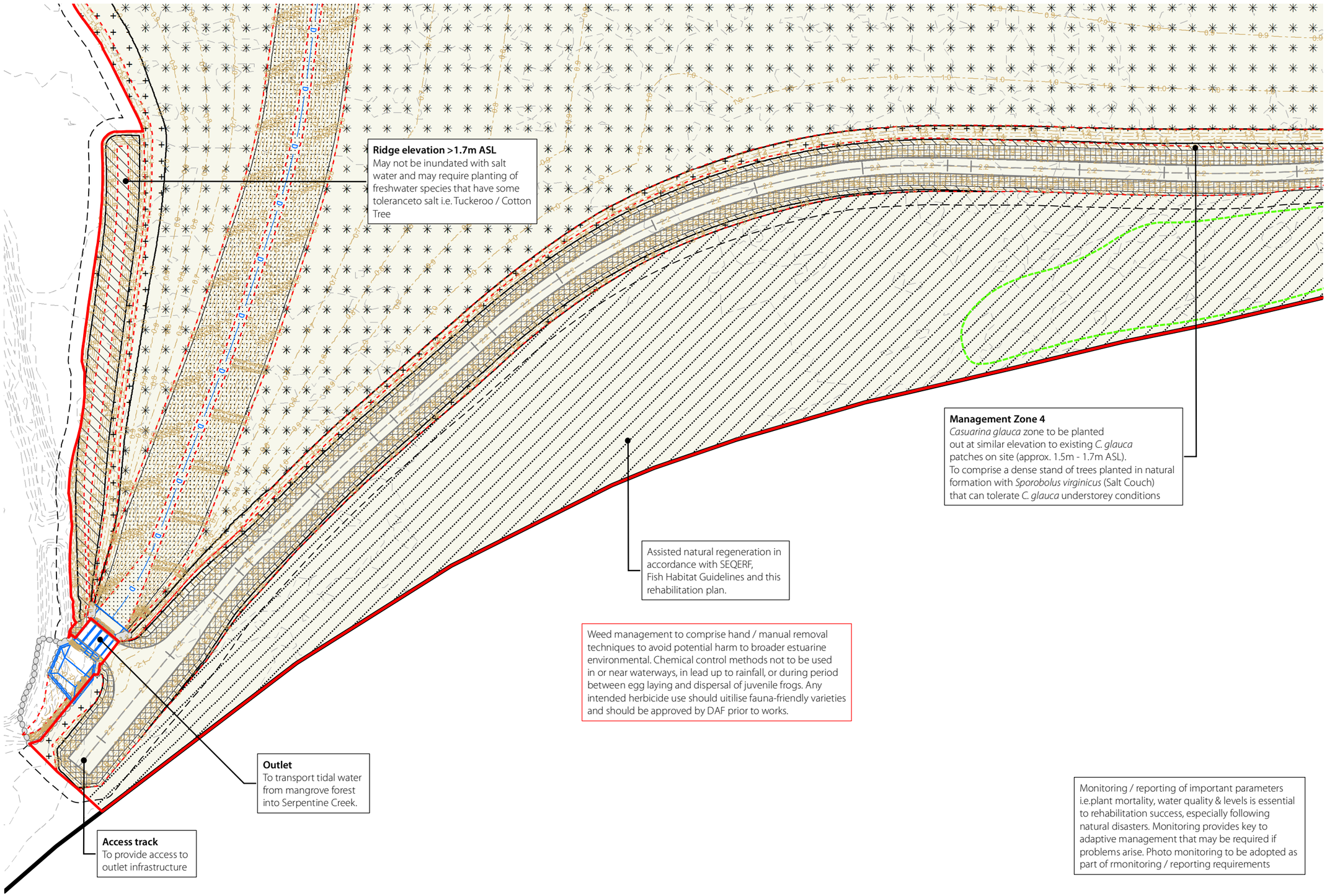
environmental management

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SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - DETAIL SHEET 10



Legend

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- Zone 2 - Mangrove
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SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

REHABILITATION NOTES

METHODOLOGY – SITE WORKS

Following resolution of the site analysis and management areas as part of rehabilitation design, prioritising site works should be considered. Prior to site works commencing, the site should be secured from degrading impacts such as grazing by stock, unauthorised access and rubbish. Some factors that may require immediate attention include:

- The presence of highly invasive weed species which may disperse further prior to substantial site works commencing
- The presence of weed species which may have a long term impact on ecological communities such as exotic and weed varieties of vines
- Flammable materials (including weed thickets, grasses and vines)
- Installation of temporary fencing where damage is being created by 4WD, motorbikes and pedestrians in core retained vegetation and ecological restoration areas.

Site works can be typically broken down into the following categories:

- Primary Works
- Follow-up Works
- Maintenance Works

Primary Works

Primary works or initial works within the site or a section of the site will commonly involve a sequence of activities such as the control of all groundcover weeds, woody weeds in the understorey and exotic vines prior to the control of weed trees. Primary work has the effect of creating a large degree of disturbance which will stimulate the germination of native and exotic species. Therefore, continuing works should be scheduled shortly after the initial visit to allow for timely control of the newly regenerating weeds.

Highly invasive weeds, such as the Restricted Invasive Plants listed under the *Biosecurity Act 2014*, should be treated as a priority during primary works to alleviate competition on native flora species and inhibit spread into newly disturbed areas. For example, canopy smothering vines such as Cat's Claw Creeper can have a detrimental impact on native canopy trees and should be prioritised over less invasive herbs such as Blue Billy Goat Weed. Some weeds will also need to be treated in stages i.e. where the weed provides protection and habitat for native fauna or bank stabilisation. For example, where Lantana is providing the only habitat for small birds, it should be removed in phases as native shrub habitat establishes.

Due to the potential negative impacts on aquatic / semi-aquatic fauna at this site—chemical control should be limited to locations away from waterways during dry periods only, and outside of period between egg laying and dispersal of juvenile frogs.

Following completion of weed management, rehabilitation (such as assisted natural regeneration, construction and fabrication planting) can occur in areas unaffected by weed management activities or areas that primary weed management activities have concluded. Refer to Rehabilitation Works notes for additional details. At the end of primary work, the zone will have been comprehensively and systematically worked, ready for follow-up works.

Follow-up (Establishment) Works

At intervals, which will vary according to the type of weed impacting the site and growing conditions, follow-up work will be necessary. This will generally involve hand / mechanical removal of newly germinating weeds and resprouting sections of woody weeds and vines. It is at this stage that observational visits should be made to the site to determine what progress the vegetation is making, and decide when to implement further follow-up work. A site that receives badly-timed, too frequent or too little follow-up will rapidly experience setbacks, as weed propagules will quickly become established in the newly disturbed areas. Germinating native seedlings may be swamped by weeds or damaged by inexperienced operators thereby exhausting the seed bank. Unless adequate follow-up can be ensured when planning restoration works, there is little point in commencing primary work, as time and resources are consumed with no substantial gain achieved (source: SEQERF).

Maintenance Works

By the maintenance stage, the vegetation community is at a point where native plant species are germinating and establishing, and canopy formation is occurring. Weed density is starting to decrease as the native plants which have been encouraged during the previous restoration works are able to out-compete the weeds. One of the fundamental principles of ecological restoration is that it attempts to create or re-establish an ecosystem that is self-sustaining. Therefore, it is the underlying goal that maintenance will eventually be decreased to a minimum. While this is not always possible, due to factors such as the continual reintroduction of weed propagules to the site from nearby residential areas; unfavourable seasons or weather event; persistent weed species; or global influences such as the enhanced greenhouse effect, it should always be strived for (source: SEQERF). Maintenance works may include minor ongoing weed management and infill planting depending on site conditions.

METHODOLOGY – WEED NOTES

Weed management typically comprises a major part of rehabilitation works. Weed management provides the basis of aiding assisted natural regeneration. It also forms part of the preliminary work required for reconstruction and fabrication scopes.

Weed Management is to be undertaken in accordance with SEQERF Primary, Follow-up and Maintenance works notes, and shall encompass all species declared at the commonwealth, state and local level, and any weeds that appear to be invasive at the site.

Critical skills for Weed Management include:

- Knowledge of relevant legislation
- Plant Identification skills
- Knowledge of different weed management techniques

Knowledge of Relevant Legislation

It is expected contractors have a depth of knowledge of relevant legislation to complete site rehabilitation works. This may include occupational Health and Safety laws as well as environmental and heritage protection legislation. Bush regenerators must comply with the requirements of the *Workplace Health and Safety Act 2011* or, when working on Commonwealth lands, the Commonwealth's *Occupational Health and Safety (Commonwealth Employment) Act 1991*. Contractors should also obtain all relevant permits required under State and Commonwealth legislation (e.g. *Nature Conservation Act 1992, Fisheries Act 1994, Vegetation Management Act 1999, Biosecurity Act 2014*). Contractors must also be aware of and adhere to cultural heritage protection obligations and any Cultural Heritage Management Plan under the *Aboriginal Cultural Heritage Act 2003* and where chemicals are in use, the *Agricultural Chemicals Distribution Control Act 1966*.

The *Biosecurity Act 2014* (Biosecurity Act), which commenced on 1 July 2016, establishes a framework to regulate and control invasive plants and animals in Queensland. Under the act, land owners are responsible for taking all reasonable and practical steps to minimise the risks associated with invasive plants and animals under their control. The *Biosecurity Act* categorises restricted matter (restricted plants and animals) into the following:

RESTRICTED MATTERS (*BIOSECURITY ACT 2014*)	
Category	**Description**
1	Must be reported to an inspector within 24 hours if it is present in, or on, something in your possession or under your control or at a place where you are the occupier, unless an appropriately authorised officer has already been advised or you possess a permit for the restricted matter. Includes red imported fire ants, electric ants, Asian honey bees, and certain animal diseases, aquatic diseases and pathogens.
2	Must be reported to an inspector within 24 hours if it is present in, or on, something in your possession or under your control or at a place where you are the occupier, unless an appropriately authorised officer has already been advised or you possess a permit for the restricted matter. includes certain noxious fish, weeds and pest animals
3	You must not distribute this restricted matter. It must not be given as a gift, sold, traded or released into the environment unless distribution or disposal is authorised in a regulation or permit. Deliberate human distribution or disposal contrary to legislation is a key source of spread to other areas. includes weeds, pest animals and noxious fish
4	You must not move this restricted matter to ensure that it does not spread into other areas of the state. includes specific weeds, pest animals and noxious fish
5	You must not possess or keep this restricted matter under your control. These pests have a high risk of negatively impacting on the environment. You may only keep this restricted matter under a permit of the *Biosecurity Act 2014* or another Act. includes weeds, pest animals and noxious fish
6	You must not feed this category of restricted matter. Feeding this restricted matter may cause their numbers to increase and negatively impact the economy or the environment. Feeding for the purpose of preparing for or undertaking a control program is exempted. Includes invasive animals such as feral deer, foxes, rabbits and wild dogs and noxious fish such as carp, gambusia and tilapia.
7	If you have these noxious fish in your possession you must kill the restricted matter and dispose of the carcass by burying the whole carcass in the ground above the high tide water mark or placing it in a waste disposal receptacle. Includes noxious fish such as carp, weatherloach, climbing perch and gambusia

In addition to the above, contractors should also be familiar with local government body requirements (e.g. Pest Management Plans, Local Codes, Policies and Guidelines) and Classifications of weeds.

A total of forty-five (45) weed species were identified on site during vegetation assessments. Eleven (11) of these are classified as Restricted Invasive Plants under the *Biosecurity Act 2014* and are listed in *Appendix B.* Four (4) of these species are also classified as Weeds of National Significance (WoNS) that have been selected nation-wide based on their level of invasiveness, potential for spread and environmental, social and economic impacts. The Redlands Coast Biosecurity Plan (2018-2023) also lists weed species that require landowner management. All weed species recorded onsite are listed in *Appendix B***.**

Plant Identification Skills

Both native and weed species should be identified prior to primary weed removal works and ongoing throughout the follow-up and maintenance periods. This is to maximise natural regeneration and reducing likelihood of accidental weed spraying to native vegetation. Regenerating species to be treated and maintained in a similar manner to newly planted revegetation tubestock. If contractor is unsure of species, advise should be sought by botanist, specialist contractor or confirmed with Queensland Herbarium.

Knowledge of Different Weed Management Techniques

A range of weed management techniques are available to combat varying weed species and scenarios. Refer to schedules below for various accepted weed management techniques.

It is important that erosion problems are not created by excessive removal of weed growth. Control techniques may be conducted mechanically or by hand in wetlands, and include weeding, mulching, mowing / slashing. Only where necessary should herbicide be used.

WEED MANAGEMENT TECHNIQUES	
METHOD	**DESCRIPTION**
Mechanical	**Involves the use of powered and non-powered equipment such as brushcutters, chainsaws, slashers, shovels, pruners, saws, etc. These methods are best used in situations where there is a large, uninterrupted stand of weeds.**
Dig and Bag	Dig and remove tuberous/ rhizomatous root systems. Remove roots or whole plant in hard/ compacted soils. Place in suitable container and remove from site, dispose of by deep burial, burn or burial at a land fill, must not place declared weed species in recycling (mulch).
Hand-Pull	Remove totally from ground by hand (human). Perform when soil is moist. Applicable to small infestations or areas of environmental sensitivity (including sensitive watercourses, when frogs are breeding, or presence of threatened sp.)
General Mechanical	May involve use of machinery (e.g. brushcutter, chainsaw, slasher, dozer, excavator). Suitable for large infestations and weed trees. Initially cost-effective, but requires immediate revegetation or matting/ mulch application & extensive maintenance periods. Generates excessive soil and vegetation disturbance.
Herbicide	**The herbicide weed control techniques described below provide a range of proven methods that can be used on a restoration site.**
Cut - Scrape-Paint	Cut the stem of the plant close to the ground (approximately 1-2cm) ensuring that soil does not come in contact with the cut surface. The cut can be made at a slight angle in order to increase the surface area that is exposed to the chemical. Apply herbicide immediately to the cut stump using poison pot and brush or dripper bottle. Using a knife, scrape the sides of the stump thoroughly to expose the green tissue. Apply herbicide to the scraped stump within 10 seconds of the cut or scrape being made in order for it to be fully effective.
Cut - Paint	Cut the stem of the plant close to ground level. Apply herbicide to the cut stump using poison pot and brush or dripper bottle. This method is best suited to easy-to-treat weeds such as small-leaved privet (Ligustrum sinense), provided that the diameter of the stem at ground level is less than approximately three centimetres. If a glyphosate-/ metsulfuron methyl herbicide mix is being used in the poison pot, a greater range of weeds can be controlled using this method e.g. Easter cassia.
Scrape - Paint	Scrape as much of the stem as possible (one side of the stem) using a knife and apply herbicide to the scrape. Leave a small section of the vine unscraped, and then twist the vine so that the next scrape is made on the opposite side of the stem to the preceding scrape. Continue along the length of the vine, scraping and painting as much of the stem as possible, with scraping to be concentrated along the thicker stems close to the root of the plant. This is the best method to use for madeira vine, as it allows the chemical to translocate to the underground storage organs and aerial tubers which may be hanging in large clusters above head height. This avoids the potential problem of tubers from cut stems left hanging in the trees from dropping to the ground and sprouting. When scraping madeira vine stems a deep scrape is advisable – scrape right through to the fibrous, stringy section of the stem, taking care not to sever the vine. This method is also suitable for treatment of ochna.
roll-hang	Vines such as mile-a-minute (Ipomoea cairica) which produce long stolons extending many metres along the surface of the ground, are suited to the roll-hang method. Locate the base of the plant and carefully pull up the runners and roll them up. The resulting roll of vine is then hung in the fork of a tree to dry out as if it is left on the ground it is likely to re-shoot. Where runners are climbing up into a tree they are cut off at head height prior to the runner being rolled up – no need to pull cut vines off trees as this action is likely to damage the tree. The base of the vine is treated using the cutscrape-paint method.
Splatter Gun	This small gas-powered injector kit is fitted into a knapsack for easy carrying and delivers large droplets in a stream over the weed. The gun is used to deliver a concentrated herbicide (glyphosate or metsulfuron methyl) across large dense expanses of weed. The method is used for species such as lantana (ratio of 1:9 of glyphosate:water). Splatter gun involves spraying strips at one to two metre intervals over the thicket. The herbicide is then translocated throughout the entire plant. The method does not require the whole plant to be covered as in over-spray.
Basal Barking	This method involves mixing an oil-soluble herbicide in diesel/kerosene and painting or spraying the full circumference of the trunk or stem of the plant from ground level to a height of approximately 45cm. Basal bark application is suitable for thin-barked woody weeds including saplings, regrowth and multi-stemmed shrubs. The method will usually result in the mortality of difficult-to-control woody weeds at any time of the year, provided the bark is not wet or too thick to enable the herbicide to penetrate. The method should not be used in wet weather, adjacent to waterways or in areas where native trees and shrubs are located. The use should be restricted to situations where a weed is particularly difficult to control e.g. cherry guava and where other methods have been unsuccessful.
roll-hang	Vines such as mile-a-minute (Ipomoea cairica) which produce long stolons extending many metres along the surface of the ground, are suited to the roll-hang method. Locate the base of the plant and carefully pull up the runners and roll them up. The resulting roll of vine is then hung in the fork of a tree to dry out as if it is left on the ground it is likely to re-shoot. Where runners are climbing up into a tree they are cut off at head height prior to the runner being rolled up – no need to pull cut vines off trees as this action is likely to damage the tree. The base of the vine is treated using the cutscrape-paint method.
Over-spraying	Over-spraying involves the use of knapsacks or power sprayers to treat large expanses of weed such as lantana thickets. The foliage must be covered with herbicide but not to point of running off the plant. The dead plants remain in place and can be cut down at a later stage. Prior to over-spraying, any weeds that are growing closely around established native plants must be hand removed or treated by cut-scrape-paint.
Spot-spraying	A knapsack filled with an appropriate herbicide mix is used by the operator to selectively control environmental weeds. A keen eye and an ability to distinguish between the native and weed species likely to be present, especially at seedling stage, is essential. Marker dye is added to the chemical mix to allow the operator to see what has already been sprayed, thus covering the ground weeds comprehensively and thoroughly Glyphosate and metsulfuron methyl are the main herbicides used for spot-spraying, together with the addition of a penetrant and/or surfactant and marker dye.
Stem Injection	Large woody weeds such as camphor laurel, coral trees (Erythrina spp, Privet Ligustrum spp) and umbrella trees are generally treated by stem-injection. Holes are drilled at regular intervals around the base of the tree and exposed roots using a drill. A tree injection syringe attached to a small capacity knapsack is used to fill the holes with the herbicide. Stem-injection of trees can also be undertaken using a hatchet to create cuts in a 'brickwork pattern' in trunks of trees for the application of herbicide (known as tree frilling). Frilling is more labour intensive than drilling. The greatest benefit of steminjection is that the trees can be left standing in situ as they die, provided there is no risk to humans or infrastructure from falling limbs. This creates convenient roosts for birds and other animals, and prevents the formation of large amounts of debris on the ground and damage to understorey plants which would result if the trees were to be cut down using a chainsaw.
Gouge-paint	This method applies to plant species that have a fleshy underground storage organ, such as the large tuber that is often found at the base of madeira vine. It is also particularly appropriate for the treatment of climbing asparagus (Protasparagus plumosus). If using this technique on climbing asparagus, first cut the stems that are growing into the canopy at head height and also at the base. The fleshy rhizome can then be gouged, or alternatively in the case of climbing asparagus, it may be struck several times firmly with the head of a pair of loppers, allowing the brown outer covering of the crown to peel away exposing the white fleshy inner section of the rhizome for application of herbicide. Gouge out sections of the fleshy base with a knife and apply herbicide using a paint pot and brush or dripper bottle within 10 seconds.
Wick Wiping	Wick wipers can be manually used with a sponge or wick applicator, attached to a container filled with herbicide or as an attachment towed by a tractor. The manual method can be used to selectively apply herbicide to the leaves of weeds growing in sensitive situations. The hand held container can leak and generally spot spraying would be recommended. The use of a tractor drawn wick wiper is used to control taller growing species such as introduced grasses and to encourage the growth of lower growing species. This method could be used in preparation for planting.

Note: Table adapted from a table in SEQERF

Weed removal in marine plant areas should conform with DAF requirements, including:

- chemicals will not to be used on marine plants
- marine plants will not to be burned
- marine plant material, and material of weeds listed under the Biosecurity Act that has been removed, damaged or destroyed, will be removed from tidal land
- the area of land, soil or sediment disturbed or compacted will be minimised
- the use of machinery will be limited. Machinery that is used will be of no greater capacity than that required for the purpose
- sediment and erosion control measures will be implemented
- works will be timed to minimise disruption to fish migration and the flowering and fruiting of the plant being trimmed
- works will be at times of limited tidal flow to limit suspension of sediment and turbidity

DAF has specified that use of herbicides is not permitted within and adjacent to waterways at the site, or leading up to times of predicted rainfall. To avoid adverse impacts to fisheries resources, any intended herbicide use should be approved by DAF prior to works. It is also recommended that herbicide use is avoided during the period of egg laying to dispersal of juvenile frogs in the local area—usually between late Autumn and early Spring, and should use fauna-friendly varieties.

Vehicle movement should also be restricted where possible to designated access tracks to minimise transmission throughout the subject site.

Inundation with saline water will prevent colonisation by many common weeds, however weed management will still be required, particularly in less frequently inundated areas. Primary weed removal will involve sensitive treatment prior to earthworks and translocation of saltmarsh sods / turf to ensure there is limited impact on native marine plants. Ongoing treatment of self-seeding weeds should occur within the new wetland and surrounding environs throughout the establishment and maintenance periods. Of particular concern, is the management of *Baccharis halimifolia* (Groundsel) which is highly prevalent in areas beyond tidal influence. Accepted management techniques for this, and other listed weed species recorded onsite are provided in *Appendix B.*

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REFERENCES:
Refer to Appendices for list of document references

AMENDMENTS:

Issue	Date	Description	Checked
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B	26/10/2020	Amended layout / 3rd Party Review	KG/NC
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D	26/10/2020	DAF / Base Updates	KG/NC

PROJECT:
38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 2/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF:
Site works, weed notes

DATE:	26/10/2020	CHECKED:	JB/NC
CLIENT REF.:	8868	DRAWN:	MC
DRAWING No.:	8868 E 11 CMRP D		

CONCEPT REHABILITATION PLAN - PEST MANAGEMENT / SITE PREPARATION

METHODOLOGY – PEST MANAGEMENT

Within the Redlands, a variety of species of mosquito and biting midge occur in association with marine, brackish and freshwaters. Each species of mosquito and biting midge occurring in the region has specific breeding habitat requirements, dispersal capabilities, patterns of activity, and ability to act as vectors for diseases affecting humans and domestic animals. The creation of a large intertidal area could result in an increased breeding and roosting habitat for several species. Fluctuating water levels may expose suitable moist substrate and leave shallow pools free from predators while rising water levels may inundate drying substrate that triggers hatching and provides suitable habitat for larval development.

A carefully constructed mangrove wetland with a well-connected, free-draining hydraulic regime and regular tidal inflows and outflows is essential for minimising potential breeding and roosting habitat. More specifically, this should involve:

- Re-profiling of site so that it doesn't impede the drainage of land up-slope.
- Minimising the occurrence of shallow pools of water (< 60 cm deep) where water was likely to stand for more than 5 days.
- Constructing simple channels, known as runnels, to allow tidal water to ebb and predatory fish to access the wetland during high tides (potential permit required under the Fisheries Act 1994).
- Orientation to encourage wind exposure (where practical).
- All inlets and openings should be covered with closely fitted, removable, mosquito-proof mesh to prevent access by adult mosquitoes, and if larvae are present, to prevent the escape of adult mosquitoes.
- Provide for vehicle access to potential breeding sites i.e. sediment trap.

External to the mangrove wetlands, the following measures are recommended to further reduce potential impacts on neighbouring communities:

- Infill existing channels and pools that hold water.
- Establishment of open space buffer zones that are either unsuitable for mosquito roosting (i.e. well drained marine couch or samphire habitat) or act as a barrier to movement (i.e. dense vegetation).
- Minimise heavy mulching and watering to discourage breeding of midge.
- Install trees with high canopies that provide air circulation at ground level.

While the initial design of water bodies may adhere to these requirements, the ongoing growth of vegetation, bank slumping, physical disturbance, accumulation of rubbish and debris, sedimentation, water quality deterioration, water management problems and general climatic conditions may facilitate the breeding of mosquitoes. As such, regular monitoring and active management is essential to any biting insect management plan (Refer to the Biting Insects Management Plan for more details on mosquito and biting midge ecology, management and monitoring requirements).

METHODOLOGY – PERMITS AND APPROVALS

Prior to site works commencing, ensure that all relevant permits and statutory approvals are obtained.

Impacts to marine plants and propagule collection for restoration

Marine plants, including mangrove and saltmarsh species, are protected under the *Fisheries Act 1994*. Marine plants, as defined under the Fisheries Act include:

- a plant (a 'tidal plant') that usually grows on, or adjacent to, tidal land, whether it is living or dead, standing or fallen
- the material of a 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

Development proposals that modify, or have a temporary or permanent loss of fish habitat require assessment by the Department of Agriculture and Fisheries (DAF) and permission is required to collect propagules or disturb them in any way.

Collection of marine plant propagules i.e. seeds, seedlings, rhizomes, cuttings, and entire plants, and movement of marine plants for approved restoration plans within their accepted distribution is supported by Qld policy, providing:

- Removal of individuals doesn't pose unjustifiable risk to source population.
- The host area has suitable and sufficient habitat for the survival of the species.
- The species being translocated is likely to have no unjustifiable adverse impact, including the spread of disease or parasites, upon the host area.
- The factors that caused the species decline in the host area have been identified are being reversed and are unlikely to recur.
- The genetic viability is not compromised at the host area.
- Other potential threats are unlikely to compromise success of translocation.
- Removal and use of mangrove seeds and propagules for mangrove rehabilitation within or immediately adjacent to the property.
- Removal of mangrove seed and propagules is by hand, within 100 km of the rehabilitation site. Mangrove Seeds or propagules must be unattached (free from the parent tree and/or the substrate).
- Removal of plants from non-tidal land for saltmarsh rehabilitation within or immediately adjacent to the subject site. Saltmarsh plants are to be removed only from non-tidal land and within 100 km of the rehabilitation site.
- After the removal of saltmarsh, substrate profiles are to be restored and divots filled with soil similar to that at the site, or with sand.
- No more than 20% of the area of a non-tidal saltmarsh patch can be removed. Plant removal must be evenly distributed across the patch.
- Biodiversity of an area is not to be reduced.
- Individual divots must not exceed 50 cm x 50 cm.
- Saltmarsh species must be consistent with the naturally occurring species assemblage at the rehabilitation site.
- This work type must be under an endorsed project plan or works associated with providing an environmental offset.
- The translocation satisfies approval requirements under the *Fisheries Act*.

The banks along Logan River and Serpentine Creek are mapped as tidal. Serpentine Creek and the south-eastern waterway are mapped as High Risk (red) waterways for waterway barrier works (WWBW). The north-eastern waterway is mapped as Low Risk (green) for WWBW. While no mapping exists, marine plants were identified on site during flora assessments by SHG.

The establishment of the mangrove wetland and salt marsh will result in:

- Direct clearing of marine plants, including *Avicennia marina* (Grey Mangrove) to create the inlet and outlet structures.
- Temporary clearing of marine plants including EPBC Act listed TEC Subtropical and Temperate Coastal Saltmarsh to establish the ground profile to support the 9.854 ha mangrove wetland / saltmarsh.
- Removal and use of mangrove seeds and propagules for mangrove rehabilitation within or immediately adjacent to the property (owned or leased).
- Removal of saltmarsh plants from non-tidal land for saltmarsh rehabilitation within or immediately adjacent to the property.

While removal of marine plants will be required for the construction of the inlet and outlet, they have been avoided to the greatest practical extent. Where earthworks are required over areas containing Salt Couch and Sea Rush, construction methods will be guided by rehabilitation experts, including Bulimba Creek Catchment Coordination Committee (B4C) and FRC Environmental, and will involve turf cut and relocation on site.

Overall, impacts to marine plants construction are considered to be minor and compensated through the creation of a 9.854 ha mangrove wetland and saltmarsh area. Subsequently, there will be a net gain in marine plants communities as a result of the action which will create terrestrial and aquatic fauna habitat.

Any impacts to marine plants collection or propagation activities will be in accordance with an endorsed Fisheries Queensland project plan and consistent with the relevant Accepted Development Requirements or a development permit appropriately authorising the removal, destruction or damage of marine plants associated with these activities. Ongoing consultation with DAF should be undertaken to ensure legislative requirements are met throughout the project.

METHODOLOGY – SITE PREPARATION

Site preparation entails modification of the habitat profile and hydrology of the site to desired conditions for artificial regeneration. Such modifications will enhance the likelihood of successful vegetation establishment. Profiling aims to prevent or limit soil erosion, eliminate areas of poor drainage and ensure that the tidal range is suitable for establishing marine plants, either through natural colonisation or by planting of selected species. Profiling will establish appropriate levels of drainage and ponding for the tidal cycle. When profiling a site, it is important to maintain some level of variation in microtopography at the site.

Further modifications may be required to prepare the site for planting and maximise growth of mangroves and saltmarsh, particularly reinstatement of existing site topsoil to appropriate levels. It is likely that the soil will require some form of amelioration i.e addition of organic matter, particularly in areas to be vegetated with saltmarsh. Site or planting preparation may also entail:

- Fencing to exclude grazing animals, people and / or vehicles (if required)
- Pre-spraying of exotic grasses and other weeds to planting areas
- Consideration of source of water for new planting (access tracks, irrigation)
- Arranging delivery of jute netting, coir logs and tree guards (if required)
- Treatment of heavily compacted soils by ripping / application of gypsum
- Identification of planting zones.

Acid Sulphate Soils

No visual evidence of ASS indicators were identified during geotechnical assessments, thus the soils are considered to be non-acid sulfate forming. Nonetheless an ASS management plan was compiled by Douglas Partners (2019) and outlines recommendations for the prevention and treatment of ASS at the site. The plan recommends application of a neutralising agent (such as ag-lime) during site works, and appropriate management of this process. The neutralising agent may be:

- Spread in key areas as part of the fill operations to intercept any acidic leachate flow.
- Added to truckloads of disturbed material while being moved, thus achieving a degree of mixing during transport and placement.
- Spread as a guard layer under any temporary or permanent stockpiles or treatment areas.
- Incorporated as lime-enriched perimeters around temporary or permanent stockpiles or treatment areas.
- Positioned in drains and areas most likely to experience flow.
- ASS Neutralisation rates for the site are provided in the management plan.

If lime neutralisation treatment is undertaken, it should be managed in a controlled environment i.e. a bunded area with perimeter drainage and a sump. This is to enable the collection and separate treatment of any acid leachate formed during the soil drying and liming process.

Saturated and cohesive soil cannot be neutralised effectively with lime, without significant reworking. Excavated soil must be dried back on a limed pad, before effective mixing can take place with earthmoving machinery. All water draining from the soil, once it is removed from any excavation, should be considered as potentially acidic and should be separated in a controlled area. The water shouldn't be allowed to flow into waterways or drains, until it has been tested for pH and other environmental tests required by the regulatory authority.

If soil is to be transported off site to be dried and neutralised, trucks should be lined to prevent leakage of wet soil, slurry or drainage water during transportation.

The soil and water contained within the treatment bunds should not be removed until the target values have been achieved. Additional soil layers should not be added to the bunded stockpile for treatment until underlying layers are validated. When testing indicates that lime neutralisation is complete, then the stockpiled soil may be removed from the liming/neutralisation pad.

Construction of excavations below the filling should also include the placement of a guard layer of fine 'ag-lime' over the exposed surfaces, to neutralise any exposed ASS. This guard layer would also serve to mitigate against low pH conditions which may be aggressive to concrete pipes and footings. Any potential effects of liming ASS on mangrove growth will also need to be considered.

Soil erosion

The subject site is located on the outside bend of the Logan river and is therefore usually prone to erosion compared to other sections of a river. Vegetation along the shoreline is comprised of sections of mangrove forest dominated by Grey Mangrove, and Saltmarsh dominated by Salt Couch. The Salt Couch area has been moderately eroded with large pieces of mud and silt washed into the river and exposed at low tide. In spite of these factors, historical imagery revealed that the river bend hasn't moved in 62 years, and is therefore relatively stable.

Nonetheless, it is important to maintain a well vegetated riverbank to protect it against future storm events (especially with increased cyclone intensity forecasted with climate change), and to prevent need for hard engineering solutions. Any development (maintenance access paths) should also be positioned as far landwards as possible to minimise any negative impacts.

Erosion within the wetland will be partially managed by the inlet and outlet structures that control tidal velocities into the wetland. Some local rock protection around those structures may be required to prevent local erosion around inlet and outlet structures, and should be carefully integrated with the naturally vegetated bank.

An Erosion and Sediment Control Plan (ESCP) should be prepared for the proposed works by a suitably qualified professional. The ESCP should be in accordance with the International Erosion Control Associations Best Practices Erosion and Sediment Control (2008).

Some roughening (preferably with materials that will decompose) of the site may be required to assist in slowing water velocity, stabilising topsoil, trapping propagules and seedlings, and to provide protection for developing vegetation. For example, coir logs and matting can be used for erosion and silt control, and will also contribute organic matter to the soil profile. DAF do not recommend the use of coir logs where possible as it may negatively impact on fish passage. However where installation is considered necessary, coir logs should be staggered to facilitate fish passage and capture sediments (see figure below).

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D	26/10/2020	DAF / Base Updates	KG/NC

PROJECT:
38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 2/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF:
Pests, permits and approvals, site preparation

DATE:	26/10/2020	CHECKED:	JB/NC
CLIENT REF.:	8868	DRAWN:	MC
DRAWING No.:	8868 E 12 CMRP D		

CONCEPT REHABILITATION PLAN - PLANTING NOTES

METHODOLOGY – PLANTING NOTES

Prior to installation of Mangrove and Saltmarsh plants at the new site, the following items should be considered:

- Species selection
- Sourcing plant material
- Nursery development
- Timing of planting
- Planting density
- Planting installation

Species Selection

Species selection is critical in achieving the desired ecological outcomes. Planting species are typically selected based on:

- Local Regional Ecosystem (RE) descriptions.
- Endemic species from the site or a neighbouring wetland.
- Climatic and weather conditions observed on site (frost, salt-spray, etc).
- Utilising flowering and fruiting species are useful to attract wildlife and result in introduction of seeds.
- Diverse vegetation layers (trees, shrubs, groundcovers).
- Species availability from seed propagation and or local nurseries, and ease of collection.
- Species with a relatively wide distribution.
- Species with the capacity to colonise tidal lands.
- Legal or other restrictions on the use of a species (all marine plants are protected in Queensland, therefore, legislative requirements must be met in the use of marine plants).

Environmental factors that may influence the suitability of species for a site include:

- Salinity;
- turbidity;
- soil characteristics (density, pH, texture, composition, nutrients);
- tidal profile;
- tidal height and range;
- inundation frequency;
- hydrology (wave action, current);
- quantity and quality of runoff;
- local species distribution and abundance;
- water quality (nitrogen, phosphorus, chlorophyll a, turbidity); and
- proximity to freshwater source and frequency of freshwater inundation.

Life strategies should also be considered when selecting species. Stress tolerant species are those that can exploit conditions of high stress and low disturbance, such as the mangroves *Rhizophora, Ceriops, Avicennia, Acanthus, Aegiceras, Bruguiera, Heritiera littoralis*, and *Cynometra iripa.* Disturbance tolerant species are those that can exploit conditions of low stress and high disturbance, such as, *Excoecaria, Lumnitzera, Xylocarpus* and *Osbornia*.

Certain species ('pioneers') are more likely to colonise a new site than others, and may either dominate, preventing the colonisation of further species, or they may create suitable conditions for later successional species to colonise. For example, *Avicennia marina* (Grey Mangrove) and *Rhizophora apiculate* (Red Mangrove) are often the pioneer, and may create a suitable, relatively stable environment, including shade and shelter, for other species, such as the *Bruguiera* spp. (Orange Mangrove) to establish. Where artificial restoration is planned for a site, the desired endpoint of successional development of the community is a major consideration when selecting suitable species.

A property search of the Regulated Vegetation Management Map (RVMM) identifies the site is predominately mapped as Category X (non-remnant vegetation) with polygons of Category B (remnant) and Category C (high value regrowth). The Supporting Vegetation Management Map (SVMM) shows that Category B is comprised of:

- Endangered RE 12.11.27 and
- Least Concern RE 12.1.2 and RE12.3.6

Endangered RE is mapped over the eastern corner of the site and along the bank of Logan River. Least Concern RE is mapped along the bank of the Logan River and along Serpentine Creek.

Category C is comprised of:

- Endangered RE 12.11.27/12.11.23/12.11.26 (60/30/10) and
- Least Concern RE 12.3.5/12.3.6 (80/20).

Least Concern RE 12.3.5/12.3.6 is also identified as wetland vegetation.

DAF protected marine plants are located on site, including in areas mapped as Category X. This includes Mangrove species consistent with RE 12.1.3 and Saltmarsh / Salt Couch Species consistent with RE 12.1.2.

Flora assessments identified plant species existing onsite that are suitable for translocation and / or planting within the Mangrove wetland / salt marsh rehabilitation. Additional species of local provenance have been recommended for inclusion at the new site. Refer to the plant schedules on *Sheet 16***.**

Sourcing Plant Material

There are a number of options for sourcing plant material for planting. It is proposed to source marine plants propagules, seeds, sods or cuttings (saltmarsh species) from adjoining tidal areas where possible. Seeds and seedlings can be sourced from nearby mangrove forests and saltmarshes under an approved rehabilitation plan. In addition, seedlings can be sourced from drains and waterways that are being cleared under a self-assessable code (e.g. by a local council, or the Port of Brisbane Authority).

With the relevant permits in place, mangrove propagules i.e. seeds and seedlings) can be translocated directly from the donor site to the receiving site, or grown at a nursery prior to planting at the receiving site. Juvenile mangroves (up to 1m tall) have also been translocated successfully—enabling shorter timeframes for soil stabilisation. Saltmarsh propagules may also be translocated directly as divots / turfs, or grown in a nursery prior to planting. Salt couch and other salt tolerant grasses have also been grown commercially as turfs.

The method of propagation will depend on the site characteristics, time available and nursery facilities to grow to maturity, availability of propagules and budget. In some conditions, mangrove seeds can grow more quickly than transplanted seedlings however this method is often limited by required timing of works.

While mangroves are generally not available as nursery stock, mangrove lilies and casuarina are commonly available, and salt couch can be grown as seedlings or turf by a variety of commercial outlets, given appropriate warning so they can establish stocks. Sourcing plants may have the following benefits:

- Awareness of genetic considerations when collecting seed.
- Experience with breaking dormancy mechanisms in hard to germinate seeds.
- Highly successful propagation techniques.
- Ability to provide high quality stock to order.
- Draw on industry resources.

Genetic hybridisation and disease need to be considered when translocating material between sites. For this reason, it is preferable that the plant donor site is close to the receiving site. It has been suggested that the donor site should not be further than 1.5 kilometres from the transplant site to ensure minimum risk of alteration of the gene pool, and to enable the benefits of species' adaptations to local conditions to be maximised.

The species to be planted and the method of planting will determine the optimum time of year for planting of seeds and seedlings at the site. Where the preferred time for collection of propagating material (e.g. seeds, seedlings, plants) does not coincide with the optimum time for planting, nursery holding of material may be required. When collecting seeds/seedlings, it is necessary to consider the impact of the works on the donor site.

Nursery Development

A nursery to hold stock may be required to ensure material is planted at optimum growth stage and season. It may be necessary to establish mangrove nurseries to hold and supply a stock of seedlings for proposed planting, as required. Where nursery development is required, reference to guidelines for the accreditation of production nurseries (NIAA 1994) will be useful. These guidelines include details on crop hygiene (root disease prevention; disease, pest and weed control), regulatory requirements, crop management practices (nutritional and environmental control) and site appearance. Careful practices in the nursery environment will help to reduce the likelihood of transfer of disease and maintain plants in optimum condition.

Mangroves may be grown in a variety of nursery conditions. Plants that have been grown under conditions similar to those found at the proposed planting site have better survival rates.

Nursery holding techniques will be influenced by the planting method to be used. Peat moss Jiffy pots have been shown to be a successful method of storing mangrove seedlings. Plants may be kept moist in ponds of brackish water with added nutrients. Prior to planting, the salinity of the pond water should be increased to that of the proposed planting site. When using peat moss Jiffy pots, seedlings may be considered ready for planting when roots have developed, and prior to their emergence from the pots. Root damage to seedlings has been correlated with increased mortality following planting. The soil medium in which nursery seedlings are grown should be the same soil into which they will eventually be planted. This allows for nursery plants to become adapted to the soil type at the site and if there is a limiting factor associated with the soil at the site, it will be identified and any remedial measures may be taken.

Detailed collection, propagation and installation techniques for recommended marine plant species at the subject site were provided by FRC Environmental (2019) and the Queensland Fisheries Guidelines and have been summarised under the 'Species Requirements' section below:

Timing of Planting

In general terms, the recommended timing of planting should ideally be during warmer weather (September to February) when plants are most active. However, timing of intertidal planting needs to be considered on a case by case basis, as there are a number of important determinants that need to be considered in the planning process. These include:

- Timing and positioning of planting relative to the tides—ensuring plantings are not washed away by water and wave action.
- The developmental stage of the transplanted material and the level of root growth on the individual plants.
- The life cycles of individual species to be planted that determines the availability of propagules.
- Location of the planting within Queensland.

Findings from the Brisbane Airport mangrove restoration project suggest that dispersal of small propagules is not recommended within a week of inundation to allow propagules to stabilise.

On the contrary, mangrove restoration projects undertaken by B4C have found better success when planting during king tides is coupled with watering, as the tides facilitate water retention and the fresh water assists growth. This finding is supported by other trials that found saltmarsh plants experience maximum germination in freshwater and are dependent on a period of reduced salinity for seed germination and seedling establishment.

The lifecycle of mangrove species proposed at the site was reviewed to determine the ultimate timing for propagule collection from nearby donor sites. *Avicennia marina* (Grey Mangrove), which is a hardy pioneer species that grows readily in the adjacent Logan River estuary, will be the dominate species planted and therefore availability of propagules will strongly influence timing of collection and primary planting. Seedlings of this species are available from July to September while all other mangrove species recommended at the site have later fruiting times that range between December to March (refer to *Appendix C*).

In light of the different fruiting times, it may be possible to undertake a primary planting in Spring consisting of Grey Mangrove propagules, with infill planting of other mangrove species occurring in Summer. Alternatively, Grey Mangrove seedlings may be stored at a nursery facility until propagules of other species are ready for translocation. *Sporobolus virginicus* (Salt Couch), *Casuarina Glauca* (Swamp She-oak) and some other salt marsh species can also be stored or grown commercially in nurseries, therefore their timing of planting with respective to their lifecycles is not as applicable.

The location of the site in South East Queensland provides additional flexibility with regards to planting times due to the relatively mild winters and warm, wet summers. For example, B4C have also found that some saltmarsh species will grow in winter in SEQ. This will provide potential contingencies whereby planting is required outside of the recommended spring – summer months.

Planting Density

Plant density is calculated on a zone by zone basis. This allows planting to cater for various requirements including standard revegetation, infill only requirements such as canopy trees at low densities. Refer to plant schedule for species and planting densities.

To determine the quantity of material required, it is necessary to establish the planting density based on the desired plant spacing. When planning the spacing of plants, it is advisable to plant equal to or more than the desired post-planting density to allow for potential mortality. Use of a grid system will ensure even planting. Planting density will influence the growth pattern of marine plants and is also likely to alter the patterns of use of the habitat by fisheries species. In some habitats, greater mangrove or seagrass density leads to high faunal abundance.

A preliminary cost – benefit analysis can help determine the quantity of material required for planting. It is important to consider the cost per propagule, the desired outcome, the most successful type of propagule, the level of protection offered by more dense planting and the impact of removal of propagules on the donor habitat.

Mangroves have been successfully planted at a variety of spacings, depending on the area, topography and available funds. Determining proper spacing should be based on minimising competition. Thinning will occur naturally, and artificial thinning can be delayed to later vegetation development stages by proper spacing.

Planting young seedlings at a density of at least one seedling per 0.5m^2 has shown to be successful—allowing room for the seedling to grow and access if thinning is required. A planting density of one seedling per 1.5m^2 was trialled at the Brisbane airport site with success. After 4 years, no evidence of self-thinning was apparent. Mangroves have also been planted at intervals of between 0.7 and 5 metres along transects.

It should be noted that given the extremely low flow velocity within the mangrove wetland, any impact of Mannings 'n' values on flow passage through the system i.e. caused be mangrove planting density, will be trivial as the mangroves will mainly be subject to inundation.

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REFERENCES:
South East Queensland Ecological Restoration Framework (2012)
Restoration of Fish Habitats: Fisheries Guidelines for Marine Areas, DPI QLd, Fish Habitat Guideline FHG 002, 44 pp.
Mangrove Nurseries: Construction, Propagation and Planting: Fisheries Guidelines, DPI Qld, Fish Habitat Guideline FHG 004, 32 pp.

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PROJECT:
38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 2/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF:
Planting notes

DATE:	23/08/2019	CHECKED:	JB/NC
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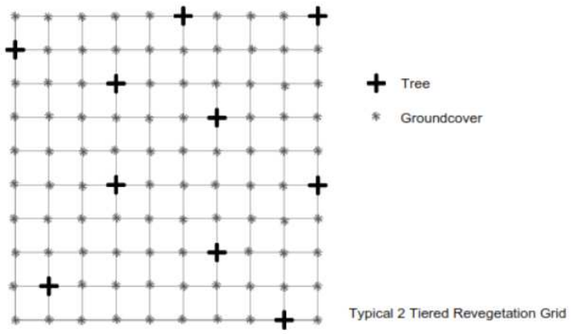
SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - NOTES

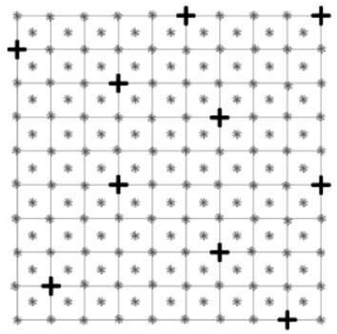
METHODOLOGY – PLANTING NOTES

Planting set out

Planting locations shall be generally set out in accordance with a typical random grid pattern as shown below. Various typical densities shown. Refer to plant schedule for species and planting densities.



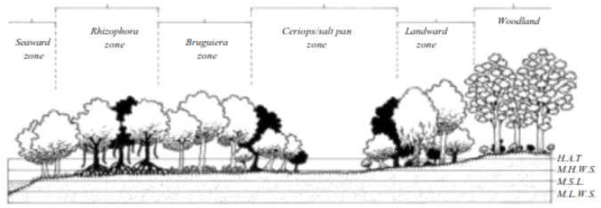
Typical 2 Tiered Revegetation Grid



Typical 2 Tiered (Dense Groundcovers) Revegetation Grid

Mangrove planting set out

Mangrove planting set out should also consider the tidal character of the site to increase the success rate of plant community establishment. If the site is at the outer edge of the mangrove fringe along a foreshore, then the use of appropriate pioneering species (e.g. *Avicennia* spp. and *Rhizophora* spp.) that are most likely to be able to sustain higher tidal inundation is recommended. If the area to be planted is a disturbance path through the tidal profile (e.g. a transect from the foreshore to the landward edge of the mangrove area), then a variety of species according to their typical occurrence in the tidal range is recommended. A typical zonation arrangement for mangroves in SEQ is shown below.



Source: Mangrove Nurseries: Construction, Propagation and Planting: Fisheries Guidelines (Clarke & Johns 2002)

Furthermore, a summary table of each species' requirements and tolerances was compiled by FRC Environmental (2019) and is provided in *Appendix C*.

Planting Installation

The following outlines the preferred installation methodology for planting activities. They have been designed to maximise plant establishment success rates and minimise plant mortality. Planting activities shall be either undertaken or directly supervised by an experienced and qualified contractor. All works shall be in accordance with the provisions of this Plan, relevant approvals and local government policies and Australian Standards.

The methods outlined below may assist with selecting planting techniques for marine habitats. Following the determination of the species for planting, it will be necessary to determine the optimum planting method on a species and case specific basis.

Mangroves

Mangroves can be planted successfully at a number of stages, depending on the species: as seeds; as newly germinated propagules; as seedlings, having developed some root structure and/or some leaf growth; and, as larger plants.

Seeds may be used to revegetate a site, however survival and success rates are generally lower than for nursery reared seeds, germinated propagules and transplanted seedlings. Seeds may be collected and raised in a nursery until at a suitable height or level of leaf growth.

Germinated propagules have a higher rate of success than planting of seeds. Germinated propagules may be collected directly from the tree, from the litter under mangrove trees, from beach wrack, or may be removed from the sediment as newly rooted young seedlings.

Mangrove seedlings can be successfully transplanted. Seedlings may either be planted in pots (usually following nursery holding), or as plugs in natural sediment. Survival of transplanted seedlings is often greater than for transplanted seeds, although the planting costs are often greater. Seedlings may be planted at varying heights. Plantings of seedlings between 15 and 50 cm high have been successful. Where seedlings are to be held for a period of time, it may be necessary to store them in peat moss Jiffy pots or plastic/poly bags. These allow transport of seedlings with limited damage to the seedling roots. Peat moss Jiffy pots may be planted directly into the sediment at the transplant site. Individual holes are required in the sediment at the transplant site to allow spreading of roots. The depth of the holes needs to be sufficient to allow the top surface of sediment in the pot to be buried with local sediment, to minimise loss of sediment during rising and falling tides.

Mangroves taller than 1m in height have been successfully transplanted in some instances. However, due to the cost of such relocation and impacts to the donor site transplanting mature trees is prohibitive. Large plants may be more suitable to stabilise a site and provide dense mangrove cover in a shorter period of time.

The following are suggestions to assist in the planting of mangroves in the field:

- Choose appropriate species for the site i.e. endemic species to avoid translocation problems
- Assemble equipment:
  - Long handled spades and shovels are useful to dig the initial hole.
  - Small garden spades assist in returning the soil around the roots once the seedling has been placed in the hole.
  - Stakes, tripods or PVC pipe may be used to stabilise seedlings.
  - Stakes should be single, short and tied to the lower trunk only, with enough expansion of the tie to allow for growth.
  - Wheelbarrows, with reduced tyre pressure, to carry plants to the site (if conditions allow).
- Ensure tides allow access below Highest Astronomical Tide (HAT) for the species to be inundated sufficiently (depending on species) or for the workers to access the planting site and plants. Schedule planting of intertidal areas during low tides.
- Dig a hole to an appropriate size for the seedling — at least 100 % more by volume than the pot size so that less compacted soils will be placed around the seedlings roots
- Dislodge the seedling from the pot with minimal disturbance by placing one hand over the top of the soil and inverting the pot into the other hand
- Gently place the plant into the hole with the roots below ground level — potting media should be level with surrounding soils
- Cover the base with surrounding soil and press until upright stability is achieved
- Stake the plant with a single, short stake, if required (or use other protective measures).

Tips for planting mangroves:

- While planting mangrove seedlings, care must be taken not to damage the roots. Increased mortality of seedlings has been associated with root damage.
- The use of growth stimulants, such as fertilisers or auxins, on seedlings may increase the amount of root growth per seedling and may enhance survival.
- The larger the root mass at planting, the better the chances for survival

Saltmarsh species

There are a variety of species of saltmarsh plants, and transplanting, rather than planting from seed, may be the more appropriate method for saltmarsh plantings. Whole plants may be transplanted as, due to their growth form, it is often possible to transplant entire saltmarsh plants, either with sediment still attached to the root systems, or following the washing of all sediment from the root system of the plants. Many of the succulent species can be grown from cuttings and can benefit from the addition of 5% seawater to the growing ponds as this reduces the risk of fungal problems. Cuttings may be taken from vegetative material of saltmarsh species that naturally root from nodes or may develop roots from vegetative fragments. These cuttings may be placed into the substrata of the site. Seeds may be collected from a variety of saltmarsh plants. However, the success, reliability and viability of revegetation using seeds are variable. It may be possible to collect the seeds of saltmarsh plants for nursery rearing.

Tips for planting saltmarsh species

- Most saltmarsh plants can be propagated in pure fresh water. It is their ability to tolerate high levels of salinity that gives them the edge in saline environments
- The use of fertilisers may be beneficial at sites that are typically nutrient poor, to allow plants to become established.
- Germination and seedling establishment of many saltmarsh plants may be dependent on a period of reduced salinity.

General planting installation notes

The follow installation methods apply in general to tubestock plantings and may be relevant for plantings at the mangrove wetland / saltmarsh area:

- Plants are to be vigorous, well established, hardened off, consistent with species or variety, free from disease and insect pests, with large root systems and no evidence of having been restricted or damaged. The landscape coordinator has the right to inspect and reject stock prior to planting
- Plants are to be planted immediately after delivery to the planting site.
- Planting is to be undertaken in accordance with the planting module contained within this drawing sheet.
- Excavate planting medium to a depth suitable for the installation of tube or pot specimens. In areas where planting substrate is deemed to be very poor (compacted, nutrient deficient, hydrophobic etc.) and above areas of potential frequent inundation and waterflow, topsoil may be used.
- Pre-water plant hole, if soil is dry, to decrease root stress upon planting and assess the infiltration of water through the soil.
- Incorporate into the planting substrate the appropriate quantity of prepared water crystals or other
- Suitable hydrating product such as Hortex 'Rainsaver' or 'Moisturaid'.
- Place plant into hole and backfill ensuring that the plant is upright and the stem is not covered in any less than 10mm or anymore than 20mm of planting medium.
- Plants are to be watered thoroughly immediately after planting (ensure deep irrigation) and thereafter as required during the construction phase of the development depending on climatic conditions. Creation of a concave hollow around the base of each plant will aid water infiltration to the plant roots.
- A complete, slow release fertiliser is recommended, and is to be administered appropriately during planting. Topdressing with slow release fertiliser is preferred to avoid toxic levels of fertiliser
- Accumulating in the plant hole around the plant roots.
- To ensure successful establishment, planting surfaces must be covered in either:
  - a 100mm layer of high quality weed-free composted chip mulch (site mulch) in locations outside of tidal / waterway influence. Note: to avoid possible stem rot in some 'drier' species ensure mulch is 'dished' and not covering plant stem by more than 20mm. Where available, mulch material to be sourced from cleared vegetation material if adequately seasoned
  - Suitable anchored natural fibre weed matting / netting installed in accordance with manufacturers recommendations
- A long-term slow release fertiliser, such as Nutricote or similar product should be used for all plantings after initial plant establishment.

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REFERENCES:
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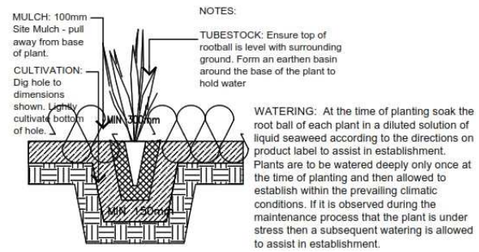
SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - NOTES

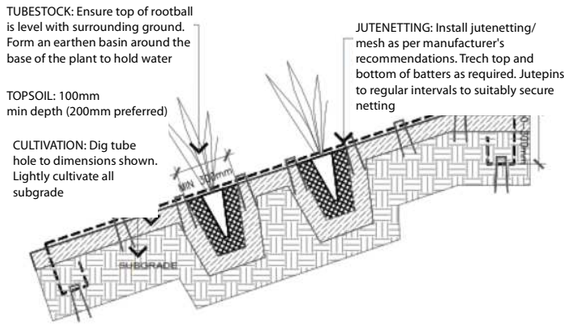
METHODOLOGY – PLANTING NOTES

Typical planting details as below for standard medium mulch installation and jute netting. Refer to manufacturer's recommendations for detailed jute netting installation including pinning, etc.

Each individual planting location should be spot cultivated to at least 2 times the depth and twice the width of the plant stock size. Refer detail for more specifications:



Where evidence of plant damage is occurring, tree guards grow tubes to be installed as required.



Jute netting mesh to be installed as per manufacturer's recommendations. Indicative detail shown only.

Species Requirements

The following provides a brief summary of species recommended for this project, including their distribution, habitat, propagation and installation requirements. Furthermore, a summary table of each species' requirements and tolerances was compiled by FRC Environmental (2019) and is provided in **Appendix C.**

Avicennia marina (Grey Mangrove):

The grey mangrove grows across the Indo-West Pacific, and has a broad tolerance of temperature, tidal inundation levels, moisture, substrate type and salinity. It grows in the high to low intertidal zone, in downstream and intermediate estuarine positions, on a wide range of substrates including unconsolidated sediment, sandy-loams, sandy- clays, medium sand, mud, rock, fine silt, solonchaks and gleys. In SEQ, propagules usually mature in September to November, with most seeds falling before January. Seedlings rapidly establish in new intertidal areas, colonising drains throughout SEQ.

The propagules are 'recalcitrant seeds' i.e. seeds without a dormancy period. The buoyant cotyledon are able to float on the tide for a short time before buoyancy is lost and they settle in the intertidal area, the root elongates, and they anchor in the sediment.

Grey mangrove forests can be established by planting seeds or transplanting seedlings. Seeds are gathered from the ground within the mangrove forest or nearby waterways. Only propagules that are unattached to either the tree or the ground should be collected. Strong winds can dislodge immature propagules so only the largest seeds should be collected. Once collected, propagules should be soaked overnight in fresh or saline water, to remove the buoyant outer husk. The best sites to actively seed mangrove plants are those that are sheltered from wave energy and have gently sloping foreshores with a muddy or silty substrate. The seeds can be hand-sewn in selected locations. Using a stick or a finger to make a hole, sprouting seeds are placed only 1–2 cm deep into the substrate. If the seed is totally covered then it may rot. To stop floating debris from pulling out the seed, the seed is positioned so that the sloping top edge is facing the water. In exposed areas seeds are often washed out of the substrate by wave action.

Transplanting mangrove seedlings is a viable method provided the seedlings are between 20–40 cm high, have 6–10 leaves and there is no peg root development. A PVC corer with a diameter of approximately 30 cm and a shovel can be used to harvest the seedlings. This allows the root mass to be excavated intact, and minimises damage to the surrounding environment. The same corer can then be used to dig a hole to plant the seedling in, with the surrounding soil also loosened to facilitate lateral growth of roots (without the development of lateral roots, seedlings can 'pop out' of the sediment and wash away).

Aegiceras corniculatum (River Mangrove):

River mangroves are restricted to the Indo-West Pacific region, growing in upstream and intermediate estuarine positions in the low intertidal zone.

In SEQ, propagules start falling in early winter. Propagules of are buoyant, therefore suited to water dispersal, and are recalcitrant seeds, with no dormant period. Seeds and seedlings can be planted in a similar way to grey mangroves.

Rhizophora stylosa (Red Mangrove):

In Australia, red mangroves are a dominant tropical mangrove, that also occurs insubtropical environments (with a southerly limit on the east coast at South West Rocks in NSW). They have characteristic arching prop roots that support the main trunk. These mangrove forms extensive, often pure stands around the shores of shallow protected bays, estuaries and inlets. While they prefer soft, well drained muddy soils, it also establishes on rock or coral-based sandy soils and is a dominant species of lower tidal mangrove forests. It is commonly seen along the lower tidal reaches of rivers and immediately behind the seaward fringe of mangroves.

Seeds germinate on the tree (vivipary), which results in a long, green, rounded propagule (seedling) about 30 cm long. The propagule protrudes through the wall of the fruit to hang vertically beneath it. This buoyant germinated seed is the first stage of the root system, and is dispersed on the tide.

Red mangroves have been less commonly used in South east Queensland (SEQ) and northern NSW restoration projects. They are likely best established by planting seedlings attached still to the fruit, rather than by transplanting rooted seedlings, as the prop roots from seedlings are likely to be easily damaged.

Excoecaria agallocha (Milky Mangrove):

Milky mangroves are found through tropical Asia, Africa and the western Pacific, and occurs in the high and mid intertidal zones but is sometimes found above the high tide mark. They prefer sandy substrates and requires freshwater input for a large part of the year. In SEQ, they are commonly found on the landward edge of mangrove forests, near the level of highest astronomical tide (HAT).

Seed germination and seedling growth is best between 0 and 5 PSU. In SEQ, propagules fall in January and February. Propagules are buoyant and germinate upon contact with the ground. Seeds are relatively small and grow in bunches, and are consequently relatively easy to collect and are good candidates for commercial propagation. As milky mangroves grow in fresher, less tidally inundated areas, seedlings grown in pots are not likely to be washed out by tidal currents.

Acrostichum speciosum (Mangrove Fern):

Mangrove Fern is restricted to tropical Indo-West Pacific, from Asia to Australia and the western Pacific. It grows in the high to mid intertidal zones, in intermediate estuarine positions. The mangrove fern is one of the first plants to colonise after a disturbance and often inhabits areas cleared of mangroves. It is particularly valuable for reducing coastal erosion and filtering nutrients and sediment. Mangrove ferns produce mature spores throughout the year.

Crinum pedunculatum (Mangrove Lily):

Mangrove Lily is found in coastal Queensland and New South Wales, and in New Guinea and on Pacific Islands in tidal areas (ANPSA 2018). It is a hardy tropical / subtropical plant and can grow in full sun, light shade and half shade. It prefers moist conditions and tolerates poor drainage. Crinum pedunculatum colonises and grows on a variety of substrates, from fine or coarse unconsolidated sediment to a variety of cultivated garden soils.

Mangrove lilies drop seeds in February and March. Mangrove lilies are easily grown from seed, which should be kept moist. Seeds sometimes germinate while still attached to the parent plant. They can also be transplanted relatively easily, as long as the entire root ball is transplanted. They are widely used in street planting in Brisbane, and seedlings of local provenance are available from commercial nurseries.

Sporobolus virginicus (Salt Couch):

Salt Couch is found on coastal margins (sand dunes and tidal wetlands) in all states of Australia and Papua New Guinea, and flowers over much of the year. Salt Couch prefers sandy soils and cannot tolerate constant inundation.

Marine couch can be successfully transplanted using sods where donor sites can be found, or by using sprigs, tube stock or turf. Marine couch tube stock of local provenance is available from commercial nurseries, given appropriate notice, with some nurseries also producing marine couch turf.

Samphires Including Suaeda spp. and Sarcocornia quinqueflora

While samphires can be transplanted as sods, these sods are prone to fall apart, and do not have as much structural integrity as sods of marine couch. These plants commonly colonise rehabilitating saltmarsh areas after floods or heavy rainfall .

Casuarina glauca (Swamp She-oak):

Swamp She-oak is found in coastal Queensland and New South Wales along rivers and saltwater estuaries. These trees, also known as swamp she-oaks, grow up to 20 m tall, with new trees often shooting from the root system. Swamp she-oak can grow in poorly drained and saline soils, and often rapidly colonise vacant coastal areas. These trees typically grows on alluvium, hydrosols, clay loam, heavy clay (greater than 50% clay), light to medium clay (35-50% clay) or loam, sandy loam, sandy clay loam and sometimes organosols (peaty soils).

Flowers appear in September to October. Cones last on the trees for at least one season and contain around 450 viable seeds per gram. No pre-treatment is required for seeds to germinate, which occurs in about 5 days. Seedlings of local provenance are available from commercial nurseries. The trees are fast growing, and can be pruned and pollarded.

Protection devices

It may be necessary to install devices to reduce the potential risk of damage to transplanted material from water and wave action (including tidal movement) and herbivores. Anecdotal evidence indicates that sediment disturbance during planting may attract fish and other fauna. Subsequent active foraging in newly disturbed sediment may dislodge freshly planted material.

Examples of protection devices include PVC piping and mesh netting. PVC piping may be used for protection of mangrove seedlings. Lengths of PVC piping may be placed over individual seedlings to protect them from wave and wind erosion and scouring from driftwood and other such impacts. For larger seedlings, PVC pipes may be arranged in a pyramid structure, attached together at the apex, and pushed into the sediment. These pyramids may be placed around seedlings and act in the same way as mangrove stilt roots (e.g. *Rhizophor*a spp.) to prevent damage from driftwood scouring and to reduce the water flow and erosion around the seedlings. Such devices may be allowed to remain at a site for a number of years. It is likely that they would not be necessary following one to two years of growth. Mesh netting may be installed over plantings where grazing by herbivores is a threat.

Note: Further information on marine plant restoration is available in the Fisheries Guidelines for Mangrove Nursery Construction, Propagation and Planting (Clarke & Johns 2002) and where applicable to Queensland, the 'Saltwater Wetland Rehabilitation Manual (New South Wales Government 2008).

METHODOLOGY – FAUNA NOTES

Consideration for fauna habitat and values should be given during rehabilitation site works and should seek to enhance and restore the existing native vegetation areas and promote safe fauna habitat and movement throughout the site and into adjoining corridors where possible. It is assumed properties adjacent to the rehabilitation scope of works will undertake individual site analysis, fauna investigations, and implement future measures as required.

These works are intended to enhance fauna habitat values across the range of coastal wetland communities—including provision of critical nursery and foraging habitat for many species of fish, crustaceans and molluscs; and valuable feeding, breeding and roosting habitat for waterbirds, including migratory species that are listed under several international treaties.

Fauna habitat value and protection

The creation of the mangrove wetland will ultimately result in a net gain in aquatic and terrestrial fauna habitat. In the interim, the project will require construction of inlet and outlet structures on tidally influenced waterways. Impacts to the Logan River have been avoiding by positioning the inlet and outlet on a modified drain and disturbed area of Serpentine Creek, respectively. Construction will involve disturbance to the bed and banks to install a culvert with floodgates at both the inlet and outlet. Backfill and rock scour protection will be placed at the culvert inlet and outlet within the waterway bed. The works will also involve reprofiling of the waterways to create a low flow channel.

The Wetland CEMP includes provisions to ensure fish do not become isolated, trapped or stranded. Furthermore, inlet and outlet structures, including floodgates and scour protection that have been designed in accordance with the State Development Assessment Provisions State Code 18: Constructing or raising waterway barrier works in fish habitats to ensure that:

- hydrologic conditions are adequate for fish passage over an adequate duration of the tidal cycle;
- tidally activated, automatic floodgates are used and the invert is at bed level;
- the operational of the floodgate will not result in adverse impacts on water quality that may harm fish or fish habitat.

Locations where freshwater influences have created ponds or pooled water may provide suitable habitat for *Crinia tinnula* (Wallum Froglet) and *Adelotus brevis* (Tusked Frog), which are listed as Vulnerable under Queensland's *Nature Conservation Act 1992*. Despite possible occurrence, neither species was recorded during targeted fauna assessments. With management and mitigation measures in place—impacts to the species are considered to be low.

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SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - NOTES

ANY CHANGES TO SPECIES AND RELATIVE QUANTITIES TO BE APPROVED BY COUNCIL AND ENVIRONMENTAL COORDINATOR PRIOR TO INSTALLATION

MANAGEMENT ZONE 2 MANGROVE FOREST

RECOMMENDED SPECIES LIST TOTAL APPROXIMATE AREA = 70,975 m². Overall minimum density approximately 1 plant per 1.5 m²)

Notes:

1) Mangrove species to be consistent with RE 12.1.3 – Mangrove shrubland to low closed forest on marine clay plains and estuaries
2) All species have been located onsite or local provenance species recommended through preliminary assessments.
3) Species to be planted in their local distribution areas only*
4) Final species composition and quantities to be determined by site suitability and availability of seedlings / plants / propagules and type of propagation used i.e. translocation of mangrove sods/divots may comprise a high density of seedlings of different species.
5) Zone extent (and subsequent plant quantities) subject to variation according to observed level of inundation and site conditions prior to planting i.e. increased levels of observed inundation may require a landward shift in the mangrove / saltmarsh zone interface, requiring greater quantities of mangrove and reduced quantities of saltmarsh species.
6) In the event, sufficient numbers cannot be met at primary planting, infill planting may occur later in 1st or 2nd year to achieve the desired densities.
7) In the event of plant mortality, species may be supplemented with other successful species from this schedule, or other locally occurring species from RE 12.1.3 technical description. that are adapted to conditions onsite.

SCIENTIFIC NAME	COMMON NAME	PLANT FORM	POT SIZE	PLANTING DENSITY	QUANTITY REQUIRED
TREES					**1 PER 1.5 m²**
Avicennia marina (P)	Grey Mangrove	Tree / shrub to 25m	As required	-	37,856 OR 80%
Aegiceras corniculatum	River Mangrove	Shrub to 4m	As required	-	1,892 OR 4%
Ceriops australis	Yellow Mangrove	Tree to 10m	As required	-	1,892 OR 4%
Excoecaria agallocha	Milky Mangrove	Tree / shrub to 15m	As required	-	1,892 OR 4%
Rhizophora stylosa	Red Mangrove	Tree to 30m	As required	-	1,892 OR 4%
Bruguiera gymnorhiza	Orange Mangrove	Tree to 20m	As required	-	1,892 OR 4%
				SUB TOTAL (MIN)	47,316
SHRUB/GROUND					**1 PER 100m²**
Acrostichum speciosum	Mangrove Fern	Fern	As required	-	354
Crinum pednuculatus	Mangrove Lily	Lily	As required	-	354
				SUB TOTAL	708
				TOTAL (MIN)	**48,024**

*= Local distribution refers to position in intertidal zone / Estuarine position; P = Pioneer species

MANAGEMENT ZONE 6 SWALE DRAIN / WEIR OVERFLOW

RECOMMENDED SPECIES LIST TOTAL APPROXIMATE AREA = 85m²

Notes:

1) All species are recorded as having some degree of salt-tolerance.
2) If species is unsuitable for location based on level of saltwater inundation, substitute with another species from these schedules, or appropriate native, local provenance species from mapped Regional Ecosystems or the WWTP / Freshwater Storage Lagoon Rehabilitation Plan.
3) Any changes to species composition to be discussed between rehabilitation supervisor, project manager and SHG

SCIENTIFIC NAME	COMMON NAME	PLANT FORM	POT SIZE	PLANTING DENSITY	QUANTITY REQUIRED
GROUND COVERS				**4 PER 1 m²**	
Juncus Kraussii	Jointed Rush	Rush	Tube	-	43
Juncus bufonius	Toad Rush	Rush			43
Fimbristylis ferruginea	Common Fingerrush	Sedge			43
Fimbristylis polytrichoides	-	Sedge			43
Isolepis nodosa	Knobby Club Rush	Sedge			42
Isolepis cernua	Nodding Club Rush	Sedge			42
Lomandra longifolia	Matrush	Sedge-like			42
Dianella caerulea	Blue Flax Lily	Sedge-like			42
				TOTAL	**340**

MANAGEMENT ZONE 4 *CASUARINA GLAUCA* WOODLAND

RECOMMENDED SPECIES LIST TOTAL APPROXIMATE AREA = 1,835 m² (Overall minimum density approximately 1 plant per 2 m²)

Notes:

1) Planting species to be consistent with RE 12.1.1 – *Casuarina glauca* woodland on marine clay plains that is mapped on site.
2) Ground cover species to be tolerant of understorey conditions created by monospecific stands of *C. glauca*.
3) Freshwater species that have some tolerance to salt i.e. Tuckeroo may be incorporated into planting at higher elevations

SCIENTIFIC NAME	COMMON NAME	PLANT FORM	POT SIZE	PLANTING DENSITY	QUANTITY REQUIRED
TREES				**1 PER 4 m²**	
Casuarina glauca	Coastal She-oak	T1	Tube	-	450
				SUBTOTAL	**458**
GROUNDCOVER				**1 PER 1 m²**	
Sporobolus virginicus	Salt Water Couch	Grass	Tube	-	1,835
				SUBTOTAL	**1.795**
				TOTAL	**2,293**

MANAGEMENT ZONE 3 SALTMARSH / SALT COUCH GRASSLAND

RECOMMENDED SPECIES LIST TOTAL APPROXIMATE AREA = 10,805 m². Overall minimum density approximately 1 plant per 1 m²

Notes:

1) Species to be consistent with RE 12.1.2 – Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains
2) All species have been located onsite or local provenance species recommended through preliminary assessments.
3) Species to be planted in their local distribution areas only* i.e Samphires to be planted at lower portion of zone as they have a higher salt-tolerance to Salt Couch
4) Final species composition and quantities to be determined by site suitability and availability of seedlings / plants / propagules and type of propagation used i.e. translocation of mangrove sods/divets may comprise a high density of seedlings of different species.
5) Zone extent (and subsequent plant quantities) subject to variation according to observed level of inundation and site conditions prior to planting i.e. increased levels of observed inundation may require a landward shift in the mangrove / saltmarsh zone interface, requiring greater quantities of mangrove and reduced quantities of saltmarsh species.
6) Final species composition and quantities to be determined by availability of seedlings / plants / propagules and type of propagation used i.e translocation of saltmarsh sods may comprise a mixture of saltmarsh species.
7) In the event of plant mortality, species may be supplemented with other successful species occurring onsite, in this rehabilitation plan or locally occurring species from RE 12.1.2 technical description.

SCIENTIFIC NAME	COMMON NAME	PLANT FORM	POT SIZE	PLANTING DENSITY	QUANTITY REQUIRED
GROUND COVERS				**1 PER 1 m²**	
Sporobolus virginicus	Salt Water Couch	Grass	As required		8.644 OR 60%
Juncus Kraussii	Jointed Rush	Rush	As required		1,080 OR 10%
Isolepis nodosa	Knobby Club Rush	Rush	As required		
Phragmites australis	Common Reed	Grass	As required		
Sarcocornia quinquenflora	Bead Weed	Samphire	As required		3,241 OR 30%
Suaeda australis	Seablite	Samphire	As required		
Tecticornia australasica	Grey Samphire	Samphire	As required		
Enchylaena tomentosa	Ruby Saltbush	Samphire	As required		
Other samphire spp.	-	Samphire	As required		
				SUB TOTAL	10,805
				TOTAL	**10,805**

MANAGEMENT ZONE 5 GREEN COUCH GRASSLAND

RECOMMENDED SPECIES LIST TOTAL APPROXIMATE AREA = 2,355 m²

Notes:

4) If species is unsuitable for location based on level of saltwater inundation, substitute with another species from these schedules, or appropriate native, local provenance ground cover species from mapped Regional Ecosystems.
5) Alternative tubestock to be installed at rate of 3 plant per 1m² and bare soil secured with jute matting or mulch / jute-netting.
6) Any changes to species composition to be discussed between rehabilitation supervisor, project manager and SHG

SCIENTIFIC NAME	COMMON NAME	PLANT FORM	POT SIZE	PLANTING DENSITY	QUANTITY REQUIRED
GROUND COVERS				**TURF / 1 PER 1 m²**	
Cynodon dactylon	Green Couch	Grass	As required	-	2,355
				TOTAL	**2,355**

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REFERENCES:

Refer to Appendices for list of document references

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D	26/10/2020	DAF / Base Updates	KG/NC

PROJECT:

38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 2/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF:
Planting species schedule, maintenance

DATE:	23/08/2019	CHECKED:	JB/NC
CLIENT REF.:	8868	DRAWN:	MC
DRAWING No.:	8868 E 16 CMRP D		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT
CONCEPT REHABILITATION PLAN - MAINTENANCE AND MONITORING

METHODOLOGY – MAINTENANCE

Maintenance, as with all ecological restoration work, is fundamental in ensuring project success.

Maintenance is required following installation of the plants, and will be the responsibility of Lendlease for the duration of the five (5) year establishment period. Responsibility for maintenance will then be given to Redland Water and /or Redland City Council (Parks), who will maintain the site in perpetuity. On-going maintenance at the site will ensure that the desired end-product—a fully-functioning system that can support itself in perpetuity, with minimal maintenance and input required—is achieved.

Maintenance of the planting includes tasks such as:

- Weeds treatment;
- Watering while plants are establishing. This is often highly variable and depends on the suite of species planted, weather conditions, tidal conditions and time of year when planted. A watering schedule may consist of watering every day for week 1, twice per week for weeks 2-6 and then weekly from weeks 6-12;
- Repair of erosion control measures and protective devices if they become damaged;
- Maintaining exclusion fencing; and
- Additional planting if required.

Additional planting may be required to replace plants that do not survive (e.g.to meet survival rate requirements, or to fill gaps). Fifty percent (50%) mortality is suggested as a threshold level for marine plants, with further planting required if mortality is over this.

Sediment removal from the bed of the channel using a low-impact method, should also be undertaken annually during the maintenance period (or as required).

A typical two (2) year maintenance schedule is provided in *Appendix D*. If maintenance is regular and thorough during the first two (2) years, maintenance requirements are likely to taper off significantly in the following years.

METHODOLOGY – MONITORING

Monitoring of the created mangrove wetland is an important tool to:

- Measure whether the created mangrove wetland is meeting the objectives for the area and its biological integrity
- Troubleshoot potential problems and develop more suitable corrective measures.
- Determine compliance with regulatory requirements

The long-term goal for the created mangrove wetland is the creation of a functional, self-sustaining tidal ecosystem. Within this broad goal there are three (3) key measurable objectives:

- Create a tidal ecosystem comprising of open water / waterway channel, mangrove & saltmarsh:
- Provide productive habitat for fish;
- Rehabilitate surrounding marine plant communities

These objectives can be measured through the implementation of a monitoring plan that incorporates construction, establishment and performance monitoring.

Construction monitoring should gather information to demonstrate that the area was constructed as planned and will support the establishment of a tidal ecosystem and achieve project objectives. Information to be collected includes the location and dimension of the area, elevations once stabilised and sediment properties. Establishment monitoring includes the low-impact collection of information on planting activities including species planted, locations of plantings (zonation) and planting densities.

Performance monitoring measures the success of the project against quantitative benchmarks such as plant survival and growth. It involves low-impact data collection, and may be supported by informal monitoring techniques, such as photo monitoring, which visually captures changes in the project over time.

Performance indicators / benchmark criteria

The utilisation of performance indicators helps to determine rehabilitation success during the maintenance period and assists in prompting when additional maintenance activities are required. A table of performance indicators is provided in *Appendix E*, and will form the basis for the monitoring plan, which will detail specific, repeatable methodology for obtaining planting data and provide reasonably realistic benchmarks that align with project objectives.

It is important for the long-term success of a habitat establishment project that both growth and survival are monitored regularly for at least a year following planting and then monitored annually. Monitoring should also correspond with flower/fruiting times to capture reproductive success.

Monitoring methods

Formal monitoring of rehabilitation works involves collecting quantitative data from transects and quadrats, or from fauna surveys and trapping. Formal monitoring provides data that cannot be measured by informal observations, and can be easily compared against quantitative performance indicators.

Monitoring of water quality parameters such as nutrient and tidal levels, uses formal monitoring to define the success of the mangrove wetland in achieving water quality objectives. Baseline water quality monitoring has already been undertaken in the vicinity of the site by Water Technology, and in the broader Logan River estuary as part of Healthy Land and Water's Ecosystem Health Monitoring Program (EHMP). Future monitoring will be undertaken in accordance with the Water Quality Monitoring Program for the site and EHMP for the broader estuary. Furthermore, monitoring of sediments and erosion will be incorporated into the Site-based Management Plan.

Similarly, monitoring the provision of productive habitats should be assessed through fish and benthic surveys. Initially it is important to demonstrate that fish can access the created mangrove wetland once suitable fish pathways are established.

Where required, fish sampling methodology should be assemblage based so that any shifts in assemblage composition (relative abundances, species richness and size distribution) will be detected over time. The sampling regime in estuarine environments needs to be comprehensive and designed to collect a representative sample of the fish community. As such, sampling methods are to include both passive and active gear types.

It is important that both fish and benthic sampling are undertaken using a standardised sampling protocol that addresses seasonality. This will enable all sites to be directly comparable so the differences between individual sites and monitoring events can be clearly demonstrated. Standardisation is achieved by using comparable gear types and effort in all sampling sites.

Informal monitoring of rehabilitation works is often less time-consuming and technical, and can be an important tool for determining ecological restoration success. Informal monitoring may occur through ongoing site inspections and note taking. Notes can then be distributed to the rehabilitation team to instigate rectification works, and can be compiled in monitoring reports.

Photo-monitoring is a cost-effective method to visually assess plant survival and growth. A permanent or semi-permanent photo point can be set up using a star picket marked with fluorescent yellow safety cap or painted timber stakes, so that a photograph may be taken of the site at regular (quarterly) intervals as it is being restored. A time series of photographs from a degraded state prior to the commencement of restoration, through the transition stages and into the maintenance stage will assist in assessing the success of the ecological establishment process. Collected site data and photos should be compiled in a 'master' monitoring report for proper record keeping.

Monitoring timeframes

Monitoring timeframes may involve a series of key milestones:

- Prestart Inspection - On site meeting prior to the initial commencement of work. Typically involves Consultant, Contractor and Assessing Authority to work through rehabilitation areas and clarify any adjustments to scope against approved works.
- Compliance Inspections - At the completion of the Primary Site Works, a compliance inspection meeting will be held with the Consultant, Contractor and Assessing Authority to inspect the works on-site in relation to the approved plans and previously agreed benchmarks performance indicators. Should the rehabilitation be a dedicated asset (open space) to the assessment manager, this inspection is commonly referred to as 'on maintenance'. For dedicated assets, a secondary compliance inspection will be required (off maintenance).
- Ongoing Monitoring Inspections- Formal and informal monitoring to occur on a regular basis as highlighted above. These inspections will generally occur throughout the process, specifically before, during and after relevant compliance inspections.

In light of the project's scale, the dynamic nature of intertidal ecosystems, and gradual increase in treated effluent released into the system over the proposed seven (7) year construction period—A monitoring timeframe of minimum ten (10) years is recommended. Monitoring during the five (5) year establishment period will be the responsibility of Lendlease, and will require quarterly monitoring in the first year while rapid changes are occurring followed by bi-monthly reporting. Monitoring responsibilities will then be handed over to Redland Water and /or Redland City Council (Parks). The monitoring program can be reviewed at this time, and a longer-term, less intensive program proposed.

Long-term monitoring of mangrove restoration projects is lacking globally, and can provide important information for future projects, including mangrove planting succession and responses to sea level rise. As such, it should be considered to fill research gaps, and provide opportunity to engage with research organisations. Ongoing monitoring will be undertaken by Redland Water and /or Redland City Council (parks) as per the Water Tech Site Based Management Plan.

METHODOLOGY – ADAPTIVE MANAGEMENT

Adaptive management is an on-going, systematic approach for improving rehabilitation outcomes by learning from existing management techniques. It is a cyclic process that involves:

1. identification of unsuccessful treatments and new threats during monitoring events
2. investigation of new and alternative treatments
3. implementation of new / alternative management strategies based on best available knowledge
4. review of new / alternative management strategies during monitoring

Adopting an adaptive approach to rehabilitation works is recommended to maximise environmental outcomes for the site.

According to the Guidelines, once an area is revegetated, the survival and growth of plants needs to be assessed, monitored and managed. Plans need to be adaptive, responding to identified issues on the site.

Where survival rates are low, it may indicate the presence of a degrading factor not previously identified or considered at the site, or incorrect zonation. It will be necessary to identify and, where possible, remove the degrading factor. Where mortality is high, subsequent plantings may be necessary. It may also be necessary to introduce new species at different stages of vegetation succession i.e. if one plant species consistently dies on a site, consider using in its place a species that is performing well.

The recommendations from all the above assessments will need to be integrated and updated, should the project advance to more advanced stages. It is also recognised that learnings from these assessments should be readily adaptable to any future changes in the conceptual design of the Mangrove wetland.

METHODOLOGY – PROGRESS REPORTING

Following implementation of this plan, it is important that the techniques/methods and outcomes are documented. This should be undertaken, even when projects are not successful, to assist with potential information gathering for future projects, particularly if problems can be documented.

Where marine plants are used in the restoration project, development of a report on the project and an outline for the long-term monitoring of the site may form part of the conditions of a development approval. The report should be sent to DAF. Where possible, a copy will be lodged in the Fisheries Library to allow access to the information for further restoration projects.

METHODOLOGY – TEAM RESPONSIBILITIES

It is also critical for all parties to understand their responsibilities as part of the overall rehabilitation 'team'.

REHABILITATION TEAM RESPONSIBILITIES	
PARTY	**DESCRIPTION**
Proponent	Ensure all consultants, contractors, sub contractors or others utilizing the area are aware of the Rehabilitation Plan. Appoint appropriate consultants and contractors to undertake works as prescribed on the drawings and conditioned by the Assessing Authority. Provide security via an uncompleted works bond and maintenance bond for the cost of works if required. Cover the costs of all necessary resources to ensure works are completed as per the approved documents.
Consultants	Brief proponent on their requirements in implementing and maintaining works as per the Rehabilitation Plan. Attend pre-start and compliance (on and off maintenance) inspections. Undertake monitoring and reporting to the Assessing Authority as set up by this document. Be available to respond to technical queries to the approved documentation when on-site conditions require changes. Liaise with the Assessing Authority throughout all stages of approval, initial works and maintenance of works.
Assessing Authority	Provide technical expertise via commentary on the approval of documentation. Reduce and release securities held against works at the completion of successful milestone inspections. Be available to respond to technical queries to the approved documentation when on-site conditions require changes. Accept and review maintenance reports as dictated in this document.
Contractor	Complete works in strict accordance with the documentation. Attend pre-start and compliance (on and off maintenance) inspections. Hold relevant licenses in applicable weed management/ revegetation/ fauna management i.e. minimum Certificate III in Conservation and Land Management, Certificate III in Horticulture, or Certificate III in Rehabilitation Construction, or equivalent experience in rehabilitation. Expertise in marine plant propagation, transplantation and rehabilitation is essential for this project. Any required insurances for scope of works and an understanding of required Laws, Act, Policies and Guidelines. Recommend changes to the documentation when specific experience or on-site conditions

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PROJECT:
38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 2/RP223470
1/SL3427, 254/S31102)

environmental management
PLAN OF:
Maintenance, monitoring reporting, adaptive management

DATE:	23/08/2019	CHECKED:	JB/NC
CLIENT REF.:	8868	DRAWN:	MC
DRAWING No.:	8868 E 17 CMRP D		

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APPENDIX A(ii) - TIDAL GLOSSARY

Australian Height Datum (AHD) – Approximate mean sea level (MSL) realised between 1966 and 1968 at tide gaugs around the coastline. Official national vertical datum for Australia.

Astronomical Tide - this is the "normal" rising and falling of the oceans in response to the gravitational influences of the moon, sun and other astronomical bodies. These effects are predictable and consequently the astronomical tide levels can be forecast with confidence.

Climate change - this is the combined effect of environmental changes as a consequence of future climate scenarios. One of these possible effects is an increase in sea water levels.

Highest Astronomical Tide (HAT) – Highest Astronomical Tide (HAT): The highest level of water which can be predicted to occur under any combination of astronomical conditions.

Lowest Astronomical Tide (LAT) - The lowest tide level which can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions.

Mean High Water Springs (MHWS) - The average of all high water observations at the time of spring tide over a period time (preferably 19 years).

Mean Low Water Springs (MLWS) - The average of all low water observations at the time of spring tide over a period of time.

Mean High Water Neaps (MHWN) - The average of all high water observations at the time of neap tide over a period time.

Mean Low Water Neaps (MLWN) - The average of all low water observations at the time of neap tide over a period of time.

Mean Water Level (MWL) – The average of all hourly water levels over the available period of record

Neap tide - The tides of decreased range or streams of decreased speed occurring semimonthly near the times of first and last quarter of the Moon.

Spring tide - The tides of increased range or tidal streams of increased speed occurring semimonthly near the times of full moon and new moon.

Storm Tide - this is the combined action of the astronomical tide and any storm surge that also happens to be prevailing at the time. Surge is the rise above normal water level as a consequence of surface wind stress and atmospheric pressure fluctuations induced by synoptic events, such as severe storms or cyclones.

Tidal prism - A volume of water exchanged between an estuary or a lagoon and the open sea during one tidal period.

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PROJECT:

38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 2/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF:

References / Tidal Glossary

DATE:	23/08/2019	CHECKED:	JB/NC
CLIENT REF.:	8868	DRAWN:	MC
DRAWING No.:	8868 E AA CRMP D		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

APPENDIX B - WEED SCHEDULE

CHEMICAL CONTROL METHODS NOT TO BE USED IN OR NEAR WATERWAYS; IN LEAD UP TO PREDICTED RAINFALL OR BETWEEN PERIOD OF EGG-LAYING TO DISPERSAL OF JUVENILE FROGS OF LOCAL PROVENANCE. ANY HERBICIDE USE TO BE APPROVED BY DAF PRIOR TO WORKS

Eleven (11) restricted invasive plant (Class 3) species under the *Biosecurity Act 2014* were identified on site. Four (4) of these species are also classified as Weeds of National Significance (WoNS). These species are listed below with effective control and removal methods adapted from the Business Queensland website.

Scientific name	Common Name	Listing	Physical control	Mechanical	Chemical control methods	Other controls
Asparagus africanus	Climbing Asparagus	Restricted, WoNS	• Prevent birds from accessing berries. • Dig out roots and dispose of them at your local waste facility. • Remove entire crown and underground stem to prevent regrowth. This requires digging underneath the central growing point and lifting it out of the ground. Any regrowth that occurs can be kept under control by regular mowing or digging out.		• There are no herbicide products specifically registered for the control of asparagus ferns grass in Queensland. However, a permit held by the Department of Agriculture and Fisheries allows people generally to use some herbicide products to control asparagus ferns as an environmental weed in various situations. • Refer to Asparagus Fern Fact Sheet for herbicide control and application rates	• No known biological control agents.
Baccharis halimifolia	Groundsel	Restricted	• Hand-pull small plants. • Dig larger plants out or cut them off more than 10cm below ground level.	• As groundsel bush is a perennial woody plant with underground growing buds, slashing or burning will rarely kill plants and will generally result in regrowth. Control regrowth promptly.	• Herbicides are effective. • See the Groundsel bush fact sheet for herbicide control and application rates.	• More than 35 different insects have been tested since 1967, with 6 now permanently established: • Rust fungus Puccinia evadens from Florida was also released in 1998 and is now established. Infection requires a moisture film on leaf or stem surface. Dry spores are spread by wind. • Three agents Puccinia evadens, Hellinsia balanotes and Rhopalomyia californica are thought to contribute to control over most of weed's range.
Cardiospermum grandiflorum	Balloon Vine	Restricted	• Manually remove small infestations. • Hand-pull roots.	• Use a brush hook or similar to remove thicker growth from top of plant.	• Combine manual and herbicide control to prevent regrowth. • See the Balloon or heart seed vine fact sheet for herbicide control and application rates.	• No known biological control agents.
Cinnamomum camphora	Camphor Laurel	Restricted	• hand pull newly established or isolated seedlings • Fire (kills plant tops but produces regrowth from base	• Remove newly established or isolated seedlings by grubbing. • Bulldoze young trees that can be completely removed. Failure to remove roots or crowns of mature trees will result in regrowth.	Herbicide • depends on size and situation of target tree. • Treating standing tree may create serious hazard to human safety or other structures when tree falls. Removing bulk of tree before treating stump is preferred in such situations. Foliar spray for young trees up to 3m tall. Basal bark spray • Trees up to 6m tall with a basal stem diameter up to 30cm and no multi-stems can be treated using basal bark or cut-stump methods, although basal bark is preferred. • When using basal bark method, spray from ground level up to 30cm or higher than where multi-stems branch. Stem injection • For trees taller than 6m, stem injection using modified axe is most practical — leave no more than 2cm between cuts. • Axe cuts for stem injection of herbicides should be made at regular intervals all around stem (or stems). Care should be taken to ensure axe leaves 'pocket' in stem, into which herbicide is immediately injected. Cuts should penetrate sapwood (just under bark), but not hard central wood. Cuts made too shallow into bark or too deep into stem will result in regrowth. Drilling holes in stem before herbicide application is not recommended. • See the Camphor laurel fact sheet for herbicide control and application rates.	• No known biological control agents.
Lantana camara	Lantana	Restricted, WoNS	Fire • Burn regularly to reduce lantana's survival, but be aware that initial kill rates will vary. Effectiveness of burning will depend on the suitability of available fuel loads, fire intensity, temperature, relative humidity, soil moisture and season. • Then re-establish pasture to provide competition to inhibit lantana seed germination. • Fire is not recommended in areas such as rainforest and wooded or plantation areas, which are not fire-tolerant.	• Stick raking or ploughing can be effective in removing standing plants. However, regrowth from stumps and/or increased seedling germination in disturbed soil is common and the site will require follow-up treatment. • Grubbing of small infestations (for example, along fence lines) can be a useful and effective way to remove plants, but is time-consuming. • Repeated slashing can also reduce lantana's vigour, exhausting its stored resources and reducing its likelihood of re-shooting. • Some locations (for example, very steep inclines or gullies) are not suitable for mechanical control options because of the danger of overturning machinery and soil erosion.	• Variation in results can be a result of inconsistent application methods, mix rates or seasonal variation. Red-flowered and pink-edged red-flowered lantana are often considered the most difficult to control because their leaves are often smaller and tougher. However, herbicides can kill these varieties if you follow application procedures carefully. • For single-stemmed lantana, basal bark spraying and cut-stump methods also give good results at any time of year (but best when the plant is actively growing). On multi-stemmed varieties, obtain best results by carefully applying herbicide to each stem. • When treating actively growing plants less than 2m tall, spray foliage overall to the point of run-off. Splatter gun techniques are also effective and particularly useful in hard-to-access areas. This is best done in autumn, when sap-flows draw the poison down into the root stock, but before night temperatures get too cold. • Remove grazing animals from spray areas during and soon after treatment. Stress can cause increased sugar levels in the leaves of lantana plants, making them more palatable. • See the Lantana fact sheet for herbicide control and application rates.	Biosecurity Queensland research programs continue to investigate agents suitable for release in Australia.Biological control alone should not be relied on to manage lantana infestations. Consider other available control techniques. The 4 most important biological control agents are: • sap-sucking bug (Teleonemia scrupulosa) • leaf-mining beetle (Uroplata girardi) • leaf-mining beetle (Octotoma scabripennis) • seed-feeding fly (Ophiomyia lantanae).Other agents such as Aconophora compressa (a stem-sucking bug) and Leptobyrsa decora (a sap-sucking bug) have caused some damage in specific geographic areas.
Opuntia stricta	Common Pest Pear	Restricted, WoNS	• Fire is an effective control method for dense prickly pear infestations. Before burning, consult Biosecurity Queensland to see if this practice is suitable for your pasture and land management practices.	• Using machinery is unsatisfactory because prickly pear pads can easily re-establish.	• Herbicides • Basal bark spraying • Cut-stump method • See the Opuntioid cacti fact sheet (PDF, 12.4MB) for herbicide control and application rates.	• 8 insects and the mite remain established in Queensland. • These biological control agents continue to keep several prickly pears under control. Not all of them attack all prickly pears. • Most successful of these species were the Cactoblastis stem-boring moth and the four cochineal mealybugs. The other agents remain but not in sufficient numbers to provide control.

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REFERENCES:

Business Queensland Website (https://www.business.qld.gov.au/).

AMENDMENTS:

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A	19/06/2020	Preliminary	KG/NC
B	26/10/2020	Amended layout / 3rd Party Review	KG/NC
C	01/09/2020	DAF Updates	KG/NC
D	26/10/2020	DAF / Base Updates	KG/NC

PROJECT:

38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 2/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF: Weed Schedule

DATE: 23/08/2019 CHECKED: JB/NC
CLIENT REF.: 8868 DRAWN: MC
DRAWING No.: 8868 E AB CRP D

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

APPENDIX B - WEED SCHEDULE

CHEMICAL CONTROL METHODS NOT TO BE USED IN OR NEAR WATERWAYS; IN LEAD UP TO PREDICTED RAINFALL OR BETWEEN PERIOD OF EGG-LAYING TO DISPERSAL OF JUVENILE FROGS OF LOCAL PROVENANCE. ANY HERBICIDE USE TO BE APPROVED BY DAF PRIOR TO WORKS

Scientific name	Common Name	Listing	Physical control	Mechanical	Chemical control methods	Other controls
Lantana montevidensis	Creeping Lantana	Restricted	Pasture management • Monitor pasture condition and spell and re sow as required. • Conservative stocking rates combined with some form of pasture spelling and judicious use of fire is likely to be the most effective way to maintain the vigour and competitive ability of native pastures. Fire • Burn regularly to reduce lantana's survival, but be aware that initial kill rates will vary. Effectiveness of burning will depend on the suitability of available fuel loads, fire intensity, temperature, relative humidity, soil moisture and season.Then re-establish pasture to provide competition to inhibit lantana seed germination	• Stick raking, dozing or ploughing can b effective in removing plants. However, regrowth from stumps and/or increased seedling germination in disturbed soil is common and the site will require follow-up treatment • Grubbing of small infestations (for example, along fence lines) can be a useful and effective way to remove plants, but is time-consuming. • Repeated slashing can also reduce creeping lantana's vigour, exhausting its stored resources and reducing its likelihood of re-shooting.	• Variation in results can be a result of inconsistent application methods, mix rates or seasonal variation, follow up application is important. • Remove grazing animals from spray areas during and soon after treatment. Stress can cause increased sugar levels in the leaves of lantana plants, making them more palatable. • See the Lantana fact sheet for herbicide control and application rates, check on the label that it is recommended for Lantana montevidensis.	• No known biological control agents
Schinus terebinthifolius	Broadleaf Pepper Tree	Restricted	• Hand-pull or chip out young plants. • Remove trees in winter.	• Felled trees may regrow from suckers for up to 18 months. If chopping, mulch branches, especially if trees have seed. Alternatively, cut trees 5cm below soil, chip away bark and nail tin plate over stump.	• Herbicides are available using foliar application, basal bark and cut-stump methods. See the Broadleaved pepper tree fact sheet for herbicide control and application rates.	• No known biological control agents
Senecio madagascariensis	Fireweed	Restricted, WoNS	• Prevent establishment by ensuring dense cover of pasture in autumn and winter. • Remove small infestations immediately.	• Chip out, bag and burn isolated plants. Wear gloves when handling fireweed plants. • Slashing is usually not effective, as it increases poisoning risk to stock and only delays flowering and seeding. • Cultivation is not recommended. • Fireweed remains toxic after being cut and becomes more attractive to stock.	• Herbicides are most effective if sprayed before plants reach maturity. However, application during flowering will be effective if higher recommended rates of herbicide are applied. • Trials have shown herbicide application in the autumn period during April provides good control. Before undertaking such programs, landholders are advised to determine infestation levels. • Effective application method in an open pasture situation is a boom spray. Follow this up by spot spraying, or pulling and bagging any regrowth or missed plants. • Boom spraying is also suitable for follow-up treatments, as it allows destruction of immature plants, which may otherwise grow to re-seed the area before they can be noticed. • Bromoxynil is effective if used on seedlings, which usually appear in autumn and early winter but may appear later following rain. Twice as much bromoxynil is needed if it is applied to plants that are just beginning to flower. Bromoxynil is less effective on mature plants, as it is a contact herbicide only. Mature plants will only be killed off where the bromoxynil comes into contact with the plant, allowing recovery of the plant from lower, untouched portions. • Conduct follow-up inspections every 4 months after initial treatment. Re-treat as required. • Unfortunately, fireweed control is often not considered until the highly visible flowers appear and it is too late for effective control with herbicide. • See the Fireweed fact sheet for herbicide control and application rates.	• Organisms can be found attacking fireweed, but any effect they have is temporary and isolated. • Orange rust (Puccinia lagenophorae) is common and often affects fireweed, particularly in lower country. • Blue stem borer moth (Patagoniodes farinari) is also common, but larvae usually develop too slowly to have an impact. • Two moths imported from Madagascar have been host tested. In controlled tests they were found to feed on important non-target plants so no releases were made. • Other potential biological control agents have been identified, but rigorous testing is needed to ensure that they do not feed on closely related Australian native plants. Investigations in South Africa are presently being undertaken.
Sphagneticola trilobata	Singapore Daisy	Restricted	• Hand pulling - can be an effective control as it can minimize soil disturbance and can instantly remove the entire weed. • Dig up runners • Dispose of waste carefully, as smallest cutting can regrow.	• Mechanical control suits larger infestations, using power tools and machinery to reduce the bulk of the problem. • Mechanical control can include slashing, mowing, dozing, harvesting, and felling.	• Foliar Spray - Herbicide is diluted with water at a specific rate, and sprayed over the foliage to point of runoff. Most suited to shrubs, grasses and dense vines less than six metres tall. • Before using any herbicide always read the label carefully and ensure that the chemical is registered for use on the target weed. All herbicides must be applied strictly in accordance with the directions on the label. • See the Singapore daisy fact sheet for herbicide control and application rates.	• No known biological control agents
Tecoma stans	Yellow Bells	Restricted	• Hand-pull seedlings or using hand tools can be an effective control as it can minimize soil disturbance and can instantly remove the entire weed • Do not break taproot if removing by hand as regrowth is likely.	• Mechanical control suits larger infestations, using power tools and machinery to reduce the bulk of the problem. • Mechanical control can include slashing, mowing, dozing, harvesting, and felling.	• Herbicides can be effective • Herbicide is diluted with water at a specific rate, and sprayed over the foliage to point of runoff. • Most suited to shrubs, grasses and dense vines less than six metres tall.	• No known biological control agents

Other species recorded onsite that are not listed under the state or commonwealth are as follows:

Scientific name	Common Name	Scientific name	Common Name	Scientific name	Common Name	Scientific name	Common Name
Ageratina riparia	Mistflower	*Digitaria didactyla*	Queensland Couch	*Nephrolepis cordifolia*	Fishbone Fern	*Sida cordifolia*	Flannel Weed
Ageratum houstonianum	Blue Billygoat Weed	*Duranta erecta*	Duranta	*Nymphaea caerulea*	Blue Water Lilly	*Solanum mauritianum*	Wild Tobacco
Alternanthera denticulata	Lesser Joy Weed	*Gomphocarpus physocarpus*	Balloon Cotton Bush	*Passiflora foetida*	Stinking Passion	*Solanum seaforthianum*	Brazlilian Nightshade
Andropogon virginicus	Whiskey Grass	*Macroptilium atropurpureum*	Siratro	*Passiflora suberosa*	Corky Passion	*Solanum torvum*	Devils Fig
Asparagus spp.	Asparagus Fern	*Mangifera indica*	Mango	*Phytolacca octandra*	Inkweed	*Strelitzia nicolai*	Giant Bird of Paradise
Bidens pilosa	Cobbler's Pegs	*Megathyrsus maximus*	Guinea Grass	*Pinus elliottii*	Slash Pine	*Syagrus romanzoffiana*	Cocos Palm
Chloris gayana	Rhodes Grass	*Melastoma lepidota*	Melastoma sp.	*Schefflera actinophylla*	Umbrella Tree	*Tetragonia tetragonoides*	New Zealand Spinach
Cirsium vulgare	Spear Thistle	*Melinis repens*	Red Natal Grass				
Crassocephalum crepidioides	Thickhead	*Murraya paniculata*	Mock Orange				

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REFERENCES:
Business Queensland Website - Weeds and diseases (2020)

AMENDMENTS:

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A	19/06/2020	Preliminary	KG/NC
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PROJECT:
38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 2/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF:
Weed treatment

DATE:	23/08/2019	CHECKED:	JB/NC
CLIENT REF.:	8868	DRAWN:	MC
DRAWING No.:	8868 E AB CRP D2		

APPENDIX C - RECOMMENDED MARINE PLANTS

Table 1 Recommended marine plants to be used on site, their fruiting period, height, tolerance to high salinity and usual tidal position.[2]

Species	Common Name	Fruiting Period	Maximum Height (m)	Tolerance to High Salinity	Tidal Position	Propagule Type
Acrostichum speciosum	Mangrove fern	All year spores	3	Very low	Low to medium intertidal	Young ferns, spores
Aegiceras corniculatum	River mangrove	Dec to March	5	Low	Low to medium intertidal	Buoyant seeds & seedlings
Avicennia marina	Grey mangrove	September to November	25	Very high	Low, medium and high intertidal	Buoyant seeds & seedlings
Ceriops australis	Yellow mangrove	January to March	10	Very high	Mid intertidal	Seed attached to fruit
Crinum pedunculatum	Mangrove lily	Feb to March	1.5	Low	High Intertidal	Seeds & seedlings
Excoecaria agallocha	Milky / blind your eye mangrove	Jan to March	15	Very low	High Intertidal	Seeds & seedlings
Hibiscus tiliaceus	Cotton tree	Feb to April	15	Low	High Intertidal	Seedlings
Cynodon dactylon	Green couch	May to Oct flowering	0.3	Low	High Intertidal	Sprigs & turfs
Isolepis nodosa	Club rush	All year	0.9	Low to moderate	High Intertidal	Seedlings
Juncus kraussii	Jointed rush	All year	0.5	Moderate	High Intertidal	Seedlings
Rhizophora stylosa	Stilt rooted mangrove	January and February	20	High	Mid to low intertidal	Seed attached to fruit
Sarcocornia quinqueflora	Bead weed	November to January	0.3	Very high	High Intertidal	Sods, small seeds
Suaeda spp.	Samphire	September to March	0.8	Very high	High Intertidal	Sods, small seeds
Sporobolus virginicus	Marine couch	All year	0.3	High	Mid to upper intertidal	Sprigs, tube stock, sods & turfs

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

APPENDIX D - INDICATIVE MANGROVE MAINTENANCE SCHEDULE

NOTE: MAINTENANCE REGIME TO BE ADAPTED OVER A FIVE (5) YEAR PERIOD, AND TO TIDAL CONDITIONS I.E MANGROVES MAY NOT REQUIRE THE SAME LEVEL WEED MANAGEMENT AS *CASUARINA GLAUCA* FOREST PLANTING THAT IS LESS FREQUENTLY INUNDATED BY SALTWATER AND MORE SUSCEPTIBILITY TO FRESHWATER WEEDS. MULCH NOT PERMITTED IN TIDAL AREA UNLESS SECURED

REHABILITATION WORKS - INDICATIVE SCHEDULE OF WORK ITEMS AND MAINTENANCE SEQUENCING (NOTE TO BE REPEATED OVER FIVE (5) YEAR PERIOD NOTING THAT MAINTENANCE REQUIREMENTS MAY TAPER OFF ONCE PLANTS ARE ESTABLISHED)

TIMING	SPRING				SUMMER			AUTUMN			WINTER			SPRING			SUMMER			AUTUMN			WINTER			SPRING			
	PRIMARY WORKS				FOLLOW-UP WORKS			FOLLOW-UP / MAINTENANCE WORKS			MAINTENANCE WORKS			MAINTENANCE WORKS			MAINTENANCE WORKS			MAINTENANCE WORKS			MAINTENANCE WORKS			MAINTENANCE WORKS			
	Month 1	Month 2	Month 3		Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	
WEEK 1	Pre-start meeting Council, Contractor and Superintendent	Weed management	Mulch spreading (where applicable) and Jute-mat installation	MILESTONE: COMPLIANCE / "ON MAINTENANCE"	Watering and Monitoring and reporting (throughout establishment)	Watering and Monitoring and reporting (throughout establishment)	Watering and Monitoring and reporting (throughout establishment)	Monitoring and reporting (watering to replacement plants only)	Monitoring and reporting	Monitoring and reporting	Monitoring (watering to replacement plants only). Photo monitoring as required		Informal monitoring and reporting	Informal monitoring and reporting. Photo monitoring as required.		Informal monitoring and reporting	Monitoring (watering to replacement plants only). Photo monitoring as required		Informal monitoring and reporting	Informal monitoring and reporting. Photo monitoring as required.		Monitoring and reporting	Informal monitoring and reporting. Photo monitoring as required.		Informal monitoring and reporting	Mulch - top up depths to 100mm and replace / repair Jutematting as required	Informal monitoring and reporting. Photo monitoring as required.	Monitoring (watering to replacement plants only)	MILESTONE: COMPLIANCE / "OFF MAINTENANCE"
WEEK 2	Initial weed management works	Soil Preparation and cultivation	Natural regeneration plants staking for identification		Weed management	Weed management	Weed management	Weed management	Weed management	Weed management	Sediment removal from channel by low impact method (as required).		Weed management	Weed management		Weed management	Weed management		Weed management	Sediment removal from channel by low impact method (as required).		Weed management	Weed management		Weed management	Natural regeneration plants - weed management	Weed management	Weed management	
WEEK 3	Weed management works	Soil Preparation and modification	Planting and Watering		Natural regeneration plants - weed management	Replacement of Failed Plants	Replacement of Failed Plants	Natural regeneration plants - weed management	Natural regeneration plants - weed management	Replacement of Failed Plants	Natural regeneration plants - weed management					Replacement of Failed Plants				Natural regeneration plants - weed management							Replacement of Failed Plants	Natural regeneration plants - weed management	
WEEK 4	Weed Management - slashing of maintenance access paths	Mulch - stockpiled on site (where applicable)	Planting and Watering		Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths		Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths		Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths		Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths		Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths		Weed Management - slashing of maintenance access paths	Replacement of Failed Plants	Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths	

COLOUR KEY TO WORK ITEMS
Weed Management
Soil Preparation and Mulching
Planting Works
Watering, Monitoring and Reporting

PREPARED BY:

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PROJECT:

38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 2/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF: Maintenance and monitoring

DATE:	23/08/2019	CHECKED:	JB/NC
CLIENT REF.:	8868	DRAWN:	MC
DRAWING No.:	8868 E AD CRMP D		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

APPENDIX E - TABLE OF PERFORMANCE INDICATORS

Performance indicator	Method of data collection	Year 1 - Baseline	Year 1 – Month 3	Year 1 – Month 6	Year 1 – Month 9	Year 2a	Year 2b	Year 3a	Year 3b	Year 4a	Year 4b	Year 5a	Year 5b
MANGROVE WETLAND													
Native plant species richness	Sample quadrats	6 species	6 species	6 species	6 species	6 species	6 species	6 species	6 species	7 species	7 species	8 species	8 species
Native plant cover	Sample transect / spatial analysis	10%	10%	10%	10%	15%	15%	20%	20%	25%	25%	30%	30%
Native plant mortality	Sample quadrats	5%	10%	15%	20%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%
Native recruitment i.e. No of seedlings not planted	Sample quadrats / spatial analysis	-	-	-	-	-	-	-	-	-	-	-	-
Native plant flowering / fruiting	Sample quadrat	-	-	-	-	-	-	-	-	-	-	-	-
Declared environmental weed cover by species	Sample quadrats	0%	<2%	<2%	<2%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Other weed cover by species	Sample quadrats	0%	<2%	<2%	<2%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
SALTMARSH WETLAND													
Native plant species richness	Sample quadrats	6 species	6 species	6 species	6 species	6 species	6 species	6 species	6 species	7 species	7 species	8 species	8 species
Native plant cover	Sample transect / spatial analysis	10%	10%	15%	15%	20%	20%	25%	25%	30%	30%	40%	40%
Native plant mortality	Sample quadrats	5%	10%	15%	20%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%
Native recruitment i.e. seedlings not planted	Sample transects / quadrats & photo monitoring	-	-	-	-	-	-	-	-	-	-	-	-
Native plant flowering / fruiting by species	Sample quadrat	-	-	-	-	-	-	-	-	-	-	-	-
Declared environmental weed cover by species	Sample quadrats	0%	<2%	<2%	<2%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Other weed cover by species	Sample quadrats	0%	<5%	<5%	<5%	<5%	<5%	<5%	<5%	<5%	<5%	<5%	<5%
CASUARINA GLAUCA FOREST													
Native plant species richness	Sample quadrats	2 species	2 species	2 species	2 species	2 species	2 species	2 species	2 species	3 species	3 species	3 species	3 species
Native plant cover	Sample transect / spatial analysis	10%	10%	15%	15%	20%	20%	25%	25%	30%	30%	40%	40%
Native plant mortality	Sample quadrats	5%	10%	15%	20%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%
Native recruitment i.e. No of seedlings not planted	Sample transects / quadrats & photo monitoring	-	-	-	-	-	-	-	-	-	-	-	-
Native plant flowering / fruiting by species	Sample quadrat	-	-	-	-	-	-	-	-	-	-	-	-
Declared environmental weed cover by species	Sample quadrats	0%	<2%	<2%	<2%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Other weed cover by species	Sample quadrats	0%	<5%	<5%	<5%	<5%	<5%	<5%	<5%	<5%	<5%	<5%	<5%
Organic litter	Sample quadrats / photo monitoring	0%	0%	0%	0%	2%	2%	3%	3%	4%	4%	5%	5%
GREEN COUCH GRASSLAND													
Native plant cover	Sample transect / spatial analysis	100%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
Declared environmental weed cover by species	Sample quadrats	0%	<2%	<2%	<2%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Other weed cover by species	Sample quadrats	0%	<2%	<2%	<2%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
ASSISTED NATURAL REGENERATION													
Native plant species richness	Sample quadrats	-	-	-	-	-	-	-	-	-	-	-	-
Native plant cover	Sample transect / spatial analysis	-	0% increase on baseline data	0% increase on baseline data	0% increase on baseline data	2% increase on baseline data	2% increase on baseline data	2% increase on baseline data	2% increase on baseline data	3% increase on baseline data	3% increase on baseline data	4% increase on baseline data	4% increase on baseline data
Native recruitment i.e. No juvenile plants (where applicable)	Sample transects / quadrats & photo monitoring	-	-	-	-	-	-	-	-	-	-	-	-
Native plant flowering / fruiting by species	Sample quadrat	-	-	-	-	-	-	-	-	-	-	-	-
Declared environmental weed cover by species	Sample quadrats	0%	<2%	<2%	<2%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Other weed cover by species	Sample quadrats	0%	<5%	<5%	<5%	<5%	<5%	<5%	<5%	<5%	<5%	<5%	<5%
Organic litter	Sample quadrats / photo monitoring	-	-	-	-	-	-	-	-	-	-	-	-
Coarse woody debris	Sample quadrats	-	-	-	-	-	-	-	-	-	-	-	-

(-) Reasonable performance indicator to be developed following collection of baseline data and confirmation of sampling technique. NOTE: Suggested sampling techniques can be derived from the Guide to determining terrestrial habitat quality prepared by State of Queensland 2014

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AMENDMENTS:

Issue	Date	Description	Checked
A	19/06/2020	Preliminary	KG/NC
B	26/10/2020	Amended layout / 3rd Party Review	KG/NC
C	01/09/2020	DAF Updates	KG/NC
D	26/10/2020	DAF / Base Updates	KG/NC

PROJECT:

38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 2/RP223470
1/SL3427, 254/S31102)

environmental management

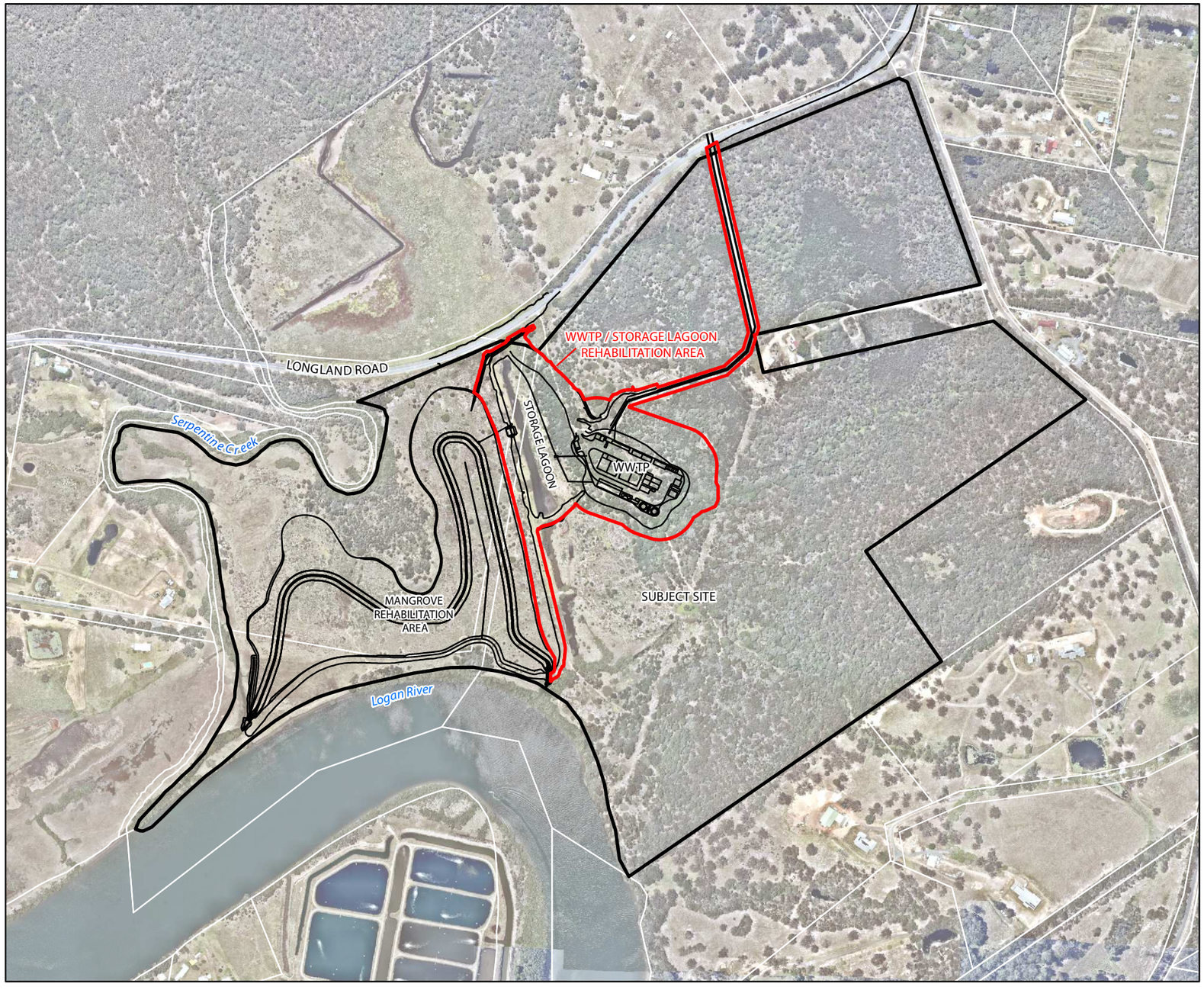
PLAN OF: Table of performance indicators

DATE:	23/08/2019	CHECKED:	JB/NC
CLIENT REF.:	8868	DRAWN:	MC
DRAWING No.:	8868 E AE CRMP D		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT WWTP / STORAGE LAGOON REHABILITATION PLAN

PLAN SET				
SHEET NO.	**TITLE**	**DESCRIPTION**	**ISSUE**	**DATE**
1	8868 E 01 CRP D	Cover sheet	D	10/11/2020
2	8868 E 02 – 03 CRP D	Rehabilitation Notes – Background/introduction	D	10/11/2020
4	8868 E 04 CRP D	Management Zones	D	10/11/2020
5-10	8868 E 05-10 CRP D	Rehabilitation Notes – Detail sheets	D	10/11/2020
11	8868 E 11 CRP D	Rehabilitation Notes – Site works / Weeds	D	10/11/2020
12	8868 E X12 CRP D	Rehabilitation Notes – Planting Notes	D	10/11/2020
13-14	8868 E 13-14 CRP D	Planting Species Schedule	D	10/11/2020
15	8868 E 15 CRP D	Rehabilitation Notes – Fauna / Maintenance	D	10/11/2020
Appendix A	8868 E AA CRP D	Appendix A - Weed treatment & Removal	D	10/11/2020



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REFERENCES:

Engineering drawings (KN Group / Stantec 2020)

Layout drawings (SHG 2020)

AMENDMENTS:

Issue	Date	Description	Checked
A	23/07/2020	Preliminary	TL/KG/NC
B	19/08/2020	DAF updates	TL/KG/NC
C	29/09/2020	DAF updates	TL/KG/NC
D	10/11/2020	WWPT updates	JB/NC

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PROJECT:

38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 3/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF:

Cover Sheet

DATE:	10/11/2020	CHECKED:	JB/NC
CLIENT REF.:	8868	DRAWN:	MC
DRAWING No.:	8868 E 01 CRP D		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - NOTES

INTRODUCTION

This Concept Storage Lagoon and Waste Water Treatment Plant Rehabilitation Plan, herein referred to as the 'rehabilitation plan', has been prepared by Saunders Havill Group (SHG) for Lendlease Communities Shoreline (Lendlease) and forms part of the Environmental Assessment Report submitted to Queensland Treasury in relation to the Southern Redland Bay Waste Water Treatment Plant (WWTP) project proposed at 38 Longland Road, Redland Bay.

Initial investigations into waste water servicing infrastructure for the Shoreline development and broader southern Redland Bay Catchment determined that there were no existing feasible options to service the region's anticipated population of approximately 13,500 equivalent persons, or up to 5,000 dwellings.

Following extensive due diligence investigations, construction of the WWTP at the subject site was agreed by all stakeholders to be the only practicable avenue for providing an ecologically sustainable solution.

This rehabilitation plan relates specifically to areas in or adjacent to the storage lagoon (SL) and WWTP, with consideration of earthworks required to construct the infrastructure, and requirements under the Bushfire Management Plan (BMP). The plan is intended to provide a clear methodology for primary and establishment works and ongoing maintenance, monitoring and reporting requirements.

This rehabilitation plan should be read in conjunction with other due diligence and site management plans, including:

- Comprehensive Report (Water Tech 2020)
- Bushfire Management Plan (LEC 2020)
- Geotech Assessment & Acid Soil Management Plan (Douglas Partners 2019)
- Biting Insects Management Plan and consultant's report (FRC Environmental 2019)
- The Recycled Water Master Plan
- Construction Management Plan (TBA)
- Concept Mangrove Rehabilitation Plan (SHG 2020)
- Vegetation Clearing & Fauna Management Plan (SHG 2020)

BACKGROUND

Contextually, the subject site is located to the south of Longland Road at Redland Bay, on an outer bend of the Logan River, about 7.5 km upstream from the mouth of the river. The Logan River spans the southern boundary of the site while Serpentine Creek spans the western boundary. The site is partly bounded by Rocky Passage Road with residential property located beyond to the east. Rural properties are located further afield to the west and south-east of the site.

The site is approximately 75 hectares (ha) and extends over four (4) lots within the Redlands City Council local government area (2/RP223470, 3/RP223470, 1/SL3427 & 254/S31102). Serpentine Creek forms the boundary between the administrative areas of Redland City and Logan City Council areas.

Vegetation

The subject site is mapped as containing remnant Endangered RE 12.11.27 and Least Concern RE 12.1.2 and composite RE12.3.5/12.3.6 (80/20). Mapping of Least Concern RE12.1.2 was confirmed along Serpentine Creek. Mapping of composite Least Concern RE12.3.5/12.3.6 and Endangered 12.11.27 was confirmed along the bank of the Logan River. Mapping of High Value Regrowth for Least Concern RE 12.3.5/12.3.6 and Endangered 12.11.27/12.11.23/12.11.26 (60/30/10) around the existing dwelling in the northern extent was corrected as part of a PMAV. The balance of the site was not surveyed and will not be impacted by the proposal.

The majority of Lot 1 SL3427 is cleared land for grazing with retained areas of vegetation located centrally on the lot.

An existing fresh water dam is located across Lot 1 on SL3427, Lot 254 on S31102 and Lot 3 on RP223470 and runs north to south—corresponding with a mapped Stream Order (SO) 1 drainage line. An area of land is cleared of vegetation adjacent to the dam on Lot 3 RP223470, the balance of land retains vegetation cover. An additional SO1 drainage line is mapped along the southeast boundary of the rehabilitation area and merges with the north to south running drainage line at its western extent. A dwelling is sited at the northern part of Lot 3 on RP223470 with access leading from Longland Road.

Vegetation at the proposed SL and WWTP sites is described as follows:

- Pre-clear mapping suggests that the entire area was historically covered with vegetation consistent with composite RE12.11.27/12.11.23/12.11.26 (60/30/10) and RE12.3.5/12.3.6 (80/20). The former dominates the eastern, more elevated portion of the site, while the latter dominates the western and southern, lower-lying portion of the site.
- A Property Map of Assessable Vegetation (PMAV) over the site determined all vegetation within the SL and WWTP area to be non-remnant, while remnant vegetation consistent with the forementioned REs was confirmed to the north, east and south of the proposed WWTP.
- The site for the proposed WWTP is located on a previously cleared western facing slope on Lot 3RP223470. The area is largely devoid of native tree species and is dominated by the weed tree *Pinus elliottii* (Slash Pine) along with other weed species including *Lantana camara* (Lantana).
- A small number of scattered native trees are located within the WWTP earthworks footprint. These include *Acacia disparrima* (Hickory Wattle), *Allocasuarina littoralis* (Black Sheoak) and *Banksia integrifolia* (Coastal Banksia). Several maturel Araucaria bidwillii (Bunya Pine) were recorded to the south-west of the site
- A linear bund is present on the western side of the freshwater dam that prevents water from entering the paddock area. The dams receive water from the waterway at the north of the site and from overland flow from the slope to the east. A bund at the southern end of the freshwater dam restricts tidal influence from two dam areas to the south..
- The banks of the fresh water dam are dominated by Baumea articulata (Jointed Twigrush) with scattered *Casuarina glauca* (Swamp She-oak). *Cinnamomum camphora* (Camphor Laurel) and *Pinus elliottii* (Slash Pine) are present on the eastern banks and slope.

Soils

The Atlas of Australia soils maps the site as containing Hydrosols (soils that are saturated with water for long periods of time). The Geological Survey of Queensland's 1:100,000 series Brisbane indicates that the site is located in an area which is underlain predominately by Alluvium typically comprising second river terrace; sand, silt clay and gravel of the Tertiary to Quaternary geological period; and along the eastern boundary of the site by Miscellaneous Unconsolidated Sediments comprising estuarine channels and banks; sandy mud, muddy sand, minor gravel of the Tertiary to Quaternary geological period. The Department of Natural Resources and Mines 1:100,000 series Acid Sulphate Soils map for Tweed Heads to Redcliffe indicates that the site is "land where ASS occurs within 5 m of the surface.

The subsurface conditions encountered during geotechnical assessments generally comprised filling over alluvial clay soils, which is in general agreement with the published geological information.

Conceptual design

The design intent for the WWTP is to treat incoming sewage and to maximise the reuse of recycled water. The WWTP conceptual design comprises a number of components:

- New staged pipelines to connect the WWTP to the reticulated waste water network
- The WWTP - to remove nutrients and pathogens (at least 99.9% of pathogens to be removed prior to discharge to wetland)
- An additional recycled water main to transfer water back to the southern Redland Bay area for re-use
- A new storage lagoon to store water before being gravity fed to the mangrove forest.
- A new mangrove forest – whereby an existing tidal inlet from the Logan River will be connected to the mangrove forest to allow water to be flushed in a one-way direction through the mangrove forest, where it will mix with flows from the WWTP before being discharged into Serpentine Creek via an outlet at the western end of the site.
- Salt Marsh – Located in the outer fringes of the proposed mangrove forest
- Mangrove forest and salt marsh areas are 9.96 4ha combined
- Deeper central flow channel – Designed to meander through the mangrove to provide maximum effluent engagement with mangroves and salt marsh areas within the site.
- Ancillary structures including a sediment forebay on the inlet to capture excess sediment and maintenance access for the sediment forebay

Construction phases

Project construction of the plant will be split into four (4) phases, with each stage providing progressively increased capacity for additional residents in line with population growth and establishment of mangrove and saltmarsh areas.

A temporary disposal / irrigation area to the north of the site is proposed during early stages of mangrove establishment. Initial inflows to the WWTP are anticipated to be relatively low due to the rate of new dwellings being constructed. The mangrove wetland will become operational once the mangroves are of sufficient size to effectively remove nutrients from the water.

Phase 1: Construction

- Year 1 – mangrove wetland constructed and planting occurs to assist establishment during construction of the WWTP.

Phase 2: No Discharge to Mangrove Wetland

- Year 2 - Wastewater transport ceases and Stage 1A of the WWTP produces recycled water which is used to supply water for construction, landscaping and irrigation. There is no excess recycled water and no discharge to mangrove wetlands via SL.

Phase 3: Increasing Discharge to Mangrove Wetland

- Years 3 & 4 – The SL is established. Additional recycled water is used for temporary irrigation. A small discharge (in extreme wet weather) is proposed through the SL to the mangrove wetland.
- Year 5 & 6 - Discharge is increased to the mangrove wetlands via the SL, with levels of discharged monitored adapted and depending on success temporary irrigation may be ceased. Stage 1B of the WWTP will be constructed.

Phase 4: Ultimate Scheme

- Year 7 – Recycled water discharge is managed between the mangrove wetland and irrigation of sports parks and ovals.

Additional earthworks to the existing fresh water dam will be required for construction of the SL in order to accommodate larger volumes of discharge from the WWTP.

In light of current / projected rates of development in the catchment—delivery of the infrastructure will be required by December 2021 with an additional 2 to 5-year timeframe before the mangrove wetland can be used as an offset.

REHABILITATION - INTRODUCTION

A substantial amount of rehabilitation research has been conducted and compiled as part of the "South East Queensland Ecological Restoration Framework (SEQERF)" and subsequently endorsed by the majority of South East Queensland councils. Given this, information provided within this CRP will largely utilize information derived from this framework.

Rehabilitation or "Ecological Restoration" can be described as "the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed" (source: Society for Ecological Restoration International).

The ability of an ecosystem to recover naturally depends on the existing natural regeneration capacity of the ecosystem i.e. resilience potential, and the level and type of disturbance, degradation or damage that has occurred. Generally, the ability of an ecosystem to naturally recover declines with increased disturbance, degradation or damage.

Determination of the resilience potential and level of degradation will assist practitioners to determine the level of effort required to restore the ecosystem. The following four ecological restoration approaches are listed under the SEQERF guidelines and are described in further detail on *Sheet 3*.

- Natural Regeneration
- Assisted Natural Regeneration
- Reconstruction
- Fabrication

In practice, sites with higher resilience potential should adopt the Natural Regeneration and Assisted Natural Regeneration approaches as these are generally the most cost-effective and encourage recruitment of locally occurring species that are adapted to local conditions. Adversely, highly degraded sites with poor resilience and an exhausted soil seed bank will likely require Reconstruction or Fabrication approaches i.e. planting to restore the ecosystem.

A key aspect of ecological restoration is that structure and function are returned to site, improving site stability, and improved habitat for fauna and flora. Structure includes vegetation height and density, canopy cover and appropriate species, as well as habitat features such as fallen logs and site rock. Function refers to the natural and self-sustaining processes occurring within the site including regeneration capacity, succession and cycling of nutrients. Activities required to achieve these objectives may include controlling environmental weeds, re-establishment of wildlife corridors and or stabilisation of creek banks or

As restoration work progresses on a site, ongoing changes to the structure and diversity of the vegetation will become apparent. These changes tend to occur in a cyclical manner, with the initial disturbance to the vegetation (either natural or man-made) being the trigger for changes. It is important to recognize that the vegetation will have to pass through a variety of stages of succession first, often over a period of years.

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REFERENCES:

South East Queensland Ecological Restoration Framework (2012)

Guideline for the preparation of a Rehabilitation Plan (GCC)

AMENDMENTS:

Issue	Date	Description	Checked
A	23/07/2020	Preliminary	TL/KG/NC
B	19/08/2020	DAF updates	TL/KG/NC
C	29/09/2020	DAF updates	TL/KG/NC
D	10/11/2020	STP updates	JB/NC

PROJECT:

38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 3/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF:

BACKGROUND / INTRODUCTION

DATE:	10/11/2020	CHECKED:	JB/NC
CLIENT REF:	8868	DRAWN:	MC

DRAWING No.: 8868 E 02 CRP D

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - NOTES

While disturbance as part of restoration works often has a negative connotation, it can also be useful for site restoration. Regeneration of native plant species is stimulated by mimicking natural disturbances. The techniques used will depend on the individual species and vegetation community, as they have evolved to respond to disturbances in different ways. Some examples of these techniques are:

- Control of competing vegetation, especially environmental weeds;
- Controlled burns or burn piles in vegetation communities adapted to fire;
- Soil disturbances such as ripping or raking; and or
- Alterations to hydrology in wetlands to reinstate natural movement.

The SEQERF also highlights that consistent follow up is critical for success of ecological restoration. This ensures that beneficial, permanent changes can occur within the vegetation community benefiting both fauna and flora. In order to be able to confirm these changes are occurring, ongoing site monitoring may also be required.

Ecological restoration is a complicated and evolving field. It requires careful consideration for all ecosystem aspects to try and minimise any unexpected interactions, although is generally accepted that not all can be fully known about each complex ecosystem. Given this, it is necessary to remain flexible throughout this process to adapt to site and natural changes.

REHABILITATION - APPROACHES

ECOLOGICAL RESTORATION APPROACHES	
NATURAL REGENERATION	
Applies:	To relatively large, intact and weed-free areas of native vegetation. Where native plants are healthy and capable of regenerating without human intervention. When native plant seed is stored in the soil or will be able to reach the site from nearby natural areas, by birds or other animals, wind or water. Where the plant community has a high potential for recovery after any short-live disturbance such as a fire or cyclonic winds. When preventative action is all that is required to avert on-going disturbances e.g. erection of fencing to prevent instruction by cattle.
Role of planting:	Planting in such areas can work against the aims of restoration by interfering with natural regeneration.
Goal	The re-establishing plant community will be similar in structure, composition and diversity to the original vegetation.
ASSISTED NATURAL REGENERATION	
Applies:	To natural areas where the native plant community is largely healthy and functioning. When native plant seed is still stored in the soil or will be able to reach the site from nearby natural areas, by birds or other animals, wind or water. Where the natural regeneration processes (seedling germination, root suckering, etc.) are being inhibited by external factors, such as weed invasion, soil compaction, cattle grazing, mechanical slashing, etc. When limited human intervention, such as weed control, minor amelioration of soil conditions, erection of fencing, cessation of slashing, etc. will be enough to trigger the recovery processes through natural regeneration. When the main management issue is weed infestation and/or current land use practices.
Role of planting:	Planting in such areas can work against the aims of restoration by interfering with natural regeneration except where species cannot return to site without direct intervention.
Goal	The re-establishing plant community will be substantially similar in structure, composition and diversity to the original vegetation.
RECONSTRUCTION	
Applies:	Where the site is highly degraded or altered. When the degree of disturbance has been so great and long-standing that the pre-existing native plant community cannot recover by natural means. To sites such as areas of fill, sites affected by stormwater flow, areas that have been drastically cleared, even though there may be a few remaining native trees or shrubs. When a greater degree of human intervention is required, such as weed control, cessation of grazing and/or slashing, amelioration of soil conditions such as importation of soils, drainage works or re-shaping of the landscape.
Role of planting:	Importation of native species to the area is required, either through planting or direct seeding (in some situations). natural regeneration and recruitment is insufficient to initially re-establish the original vegetation. Depending on the prevailing circumstances, the planting of a broad diversity of species from the target ecosystem may be unnecessary and the use of pioneers may be sufficient to re-establish ecological processes.
Goal	The re-establishing planted community should be similar to the original vegetation in structure, composition and diversity.
FABRICATION (TYPE CONVERSION)	
Applies:	Where site conditions have been irreversibly changed. When it is not possible to restore the original native plant community. Where a better-adapted local plant community can be planted that will function within the changed conditions. In situations such as the construction of a wetland plant community to mitigate increased urban storm-water run-off.
Role of planting:	Revegetation (planting) is the major component in a fabrication program.
Goal	The re-establishing planted community should be similar to a naturally occurring plant community of the same type (e.g. a constructed freshwater storage lagoon should resemble a natural system in terms of structure, composition and diversity).

Note: Table adapted from City of Gold Coast's 'Guideline for the preparation of a Rehabilitation Plan'

While natural regeneration of the subject site would cost significantly less to establish, and is the preferred position in the Guidelines—this process can be slow, particularly where, as at this site, there has been a high level of disturbance caused by previous land uses, weed incursions and civil works. This can then lead to erosion where exposed soils are not adequately stabilised by native vegetation.

As such, reconstruction techniques are recommended at disturbed locations where site topography is unchanged and is able to support vegetation from the original ecosystem. Alternatively, Fabrication is recommended at disturbed locations where the site topography has been modified i.e. downstream of stormwater outlets, or a different land use is proposed i.e. Bushfire Protection Zone. Active vegetation has been recommended throughout the rehabilitation area to minimise the period of time required to attain a functional ecosystem.

REHABILITATION - METHODOLOGY

Detailed assessment of site conditions prior to commencement of documentation is essential. As part of most rehabilitation scopes, it is worth considering an appropriate methodology for both compiling documentation and site works. This can be broken down into the following items:

- Site assessment
- Rehabilitation design documentation
- Site works
- Maintenance, monitoring and reporting

METHODOLOGY – SITE ASSESSMENT

Detailed assessment of site conditions prior to commencement of documentation is essential in the establishment of a site-specific ecological restoration methodology. In accordance with the SEQERF. The following checklist will for part of the site assessment process:

- Describe the history and background of the site
- Describe the soil, drainage, topography and aspect
- Describe the native vegetation on the site and along site boundaries
- Describe the weeds on site
- Describe the vegetation dispersal and structure
- Describe the fauna use onsite
- Describe estimated native regeneration response.

The responses to the above checklist will provide the basis of the proposed restoration approach from Natural Regeneration to Fabrication for each treatment area within this Rehabilitation Plan.

Consideration should be made in the importance of integrating site-specific measures for fauna habitat and movement. With many fauna species having specific habitat requirements, foraging patterns and movement patterns. During the site assessment process, the following provisions should be taken into consideration:

- Fauna movement opportunities via easements, tracts, utility corridors and or infrastructure pathways;
- Diversity and type of fauna and distribution on site;
- Habitat opportunities e.g. Dense foliage, roosting areas, log hollows and potential nesting boxes;
- Fauna disturbance and vicinity of works to significant nesting areas and or fauna movement;
- Distribution of significant specialized food resources e.g. Koala trees; and
- Stage weed removal and or altering of weed control technique if the weeds are currently forming a significant fauna habitat.

For the sake of keeping this RMP concise, site analysis results are compiled under a separate template, and may or may not be included in this set, however the analysis outcomes derive the Rehabilitation design methodology.

As part of the development application and due diligence reporting, terrestrial flora and fauna surveys were undertaken by SHG, aquatic surveys were undertaken by FRC Environmental, geotechnical assessments were undertaken by Douglas Partners and hydraulic modelling / hydrological assessments were undertaken by Water Technology. Furthermore, the above assessments were peer reviewed by individuals and academics who have demonstrated expertise in the various aspects of mangrove wetland / saltmarsh rehabilitation.

METHODOLOGY – REHABILITATION DESIGN

This documentation has been compiled through processes outlined in the SEQERF, site analysis and previous rehabilitation project experiences. The rehabilitation design—comprising distinct management zones—provides assessment managers, clients and contractors a clear methodology to assist the recovery of an ecosystem(s) that has been degraded, damaged or destroyed.

Rehabilitation zones were identified through detailed site analysis and are described on *Sheet 4*.

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REFERENCES:
South East Queensland Ecological Restoration Framework (2012)
Guideline for the preparation of a Rehabilitation Plan (GCC)

AMENDMENTS:

Issue	Date	Description	Checked
A	23/07/2020	Preliminary	TL/KG/NC
B	19/08/2020	DAF updates	TL/KG/NC
C	29/09/2020	DAF updates	TL/KG/NC
D	10/11/2020	STP updates	JB/NC

PROJECT:
38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 3/RP223470
1/SL3427, 254/S31102)

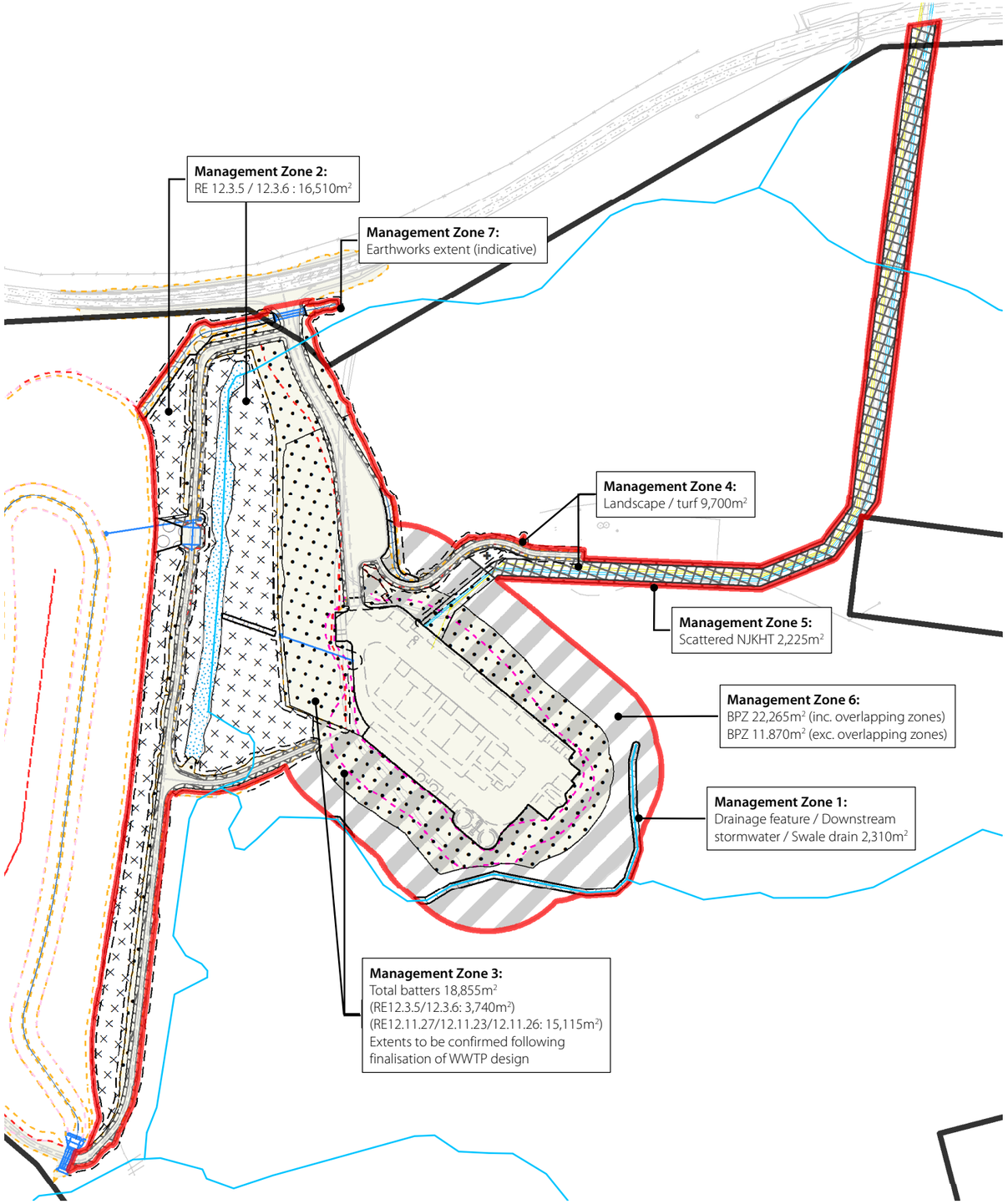
environmental management

PLAN OF:
BACKGROUND / INTRODUCTION

DATE:	10/11/2020	CHECKED:	JB/NC
CLIENT REF:	8868	DRAWN:	MC
DRAWING No.:	8868 E 03 CRP D		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - MANAGEMENT ZONES



Management Zone 1: Drainage feature / Downstream stormwater outlet / swale drain (Fabrication)

Zone to be finalised by civil contractor appropriately prior to rehabilitation works, including, but not limited to: cultivation and scarification to media, installation of final media profile to approved levels / depths, and conducting all tests (flow, conductivity etc.) as required by the assessment manager.

Weed mngmt in accordance with the South East Queensland Ecological Restoration Framework (SEQERF) and Redlands Coast Biosecurity Plan 2018-2023 (RCBP) to remove any self-seeding weed species. Sensitive weed management to minimise harm to the broader freshwater / estuarine environment. Ongoing weed management throughout maintenance period to reinforce primary weed removal.

Highly durable natural fibre matting to be installed throughout zone with additional protective devices i.e. coir logs to be installed as required.

Tubestock planting of groundcovers at rate of 4 per 1m² and to comprise of a mixture of species tolerant of periodic inundation. Areas that may be exposed to saltwater inundation i.e. channel near mangrove rehabilitation area may require substitution with salt-tolerant species. All species to be local provenance from mapped Pre-Clear Regional Ecosystem (RE) over site. Species in BMZ to be 'less flammable'.

Management Zone 2: RE 12.3.5 / 12.3.6 & Storage Lagoon (Reconstruction)

Weed mngmt in accordance with SEQERF and RCBP to encourage natural regeneration by reducing competition. Sensitive weed mngmt to minimise harm to broader freshwater / estuarine environment. Ongoing weed mngmt during maintenance period to reinforce primary weed removal.

Soil stabilisation to be provided by existing pasture grass, a highly durable natural fibre matting, or combination of aged mulch (100mm thick) and natural fibre netting at discretion of rehabilitation supervisor. Jute mat squares recommended where existing pasture grass retained. Bare areas impacted by earthworks to be treated as per Management Zone 6. Additional protective devices i.e. coir logs or tree guards to be installed as required.

Tubestock planting of trees, shrubs and groundcovers throughout zone at rates of 1:10, 1:5 and 2:1 plants per square metre respectively. To comprise a mixture of hardy species that are tolerant of regular to periodic inundation. Plants to be positioned according to level of tolerance to inundation. All species to be local provenance from mapped Pre-Clear RE 12.3.5/12.3.6. *Casuarina glauca* (Coastal She-oak) and other salt-tolerant species to be incorporated into planting adjacent Mangrove wetland as contingency for shift in level of saltwater inundation.

Management Zone 3: Earthworks Batters (Reconstruction)

Zone to be finalised by civil contractor appropriately prior to rehabilitation works as per Management Zone 1. Weed mngmt as per Management Zone 1 to remove any self-seeding weed species. Ongoing weed management during maintenance period to reinforce primary weed removal.

Soil stabilisation to occur through installation of aged forest mulch (100mm thick) at elevated locations not prone to inundation or washout, and either a highly durable natural fibre matting, or combination of aged forest mulch (100mm thick) and natural fibre netting at locations prone to inundation or washout. Additional protective devices i.e. coir logs or tree guards to be installed as required.

Tubestock planting of trees, shrubs and groundcovers at rates of 1:10, 1:5 and 2:1 plants per square metre respectively. Plant species to be selected according to site conditions and pre-clear RE at that location i.e. elevated locations to west to comprise Land Zone 11 species whereas storage lagoon batters to comprise mixture of Land zone 3 species at lower elevations and Land zone 11 species at higher elevations. All species to be local provenance from mapped Pre-Clear RE(s).

Management Zone 4: Landscape Turf Buffer & Powerline / Services Easement (Fabrication)

Zone to comprise a minimum 2-metre buffer either side of service access tracks and infrastructure requiring maintenance, as well as a clearance zone to allow for maintenance in powerline / trunk services easement.

Area to be finalised by civil contractor appropriately prior to rehabilitation works as per Management Zone 1. Weed mngmt as per Zone 1 to remove self-seeding weeds.

Installation of a native, low-maintenance turf i.e. Green Couch throughout 2-metre buffer and sections of easement intersected by a drainage line. Balance of easement to be hydroseeded (or similar).

Ongoing weed mngmt, reapplication of hydroseed / turf as required and maintenance i.e. slashing / mowing throughout maintenance period to reinforce primary works. All works in powerline easement to be in accordance with Energy Queensland Work Category Specification WCS1.6.

Management Zone 5: Scattered Non-juvenile Koala Habitat Trees adjacent Powerline / Services Easement (Fabrication)

Area to be finalised by civil contractor appropriately prior to rehabilitation works as per Zone 1. Weed mngmt as per Zone 1 to remove self-seeding weeds.

Installation of a native, low-maintenance turf i.e. Green Couch in sections of zone intersected by a drainage line. Balance of groundlayer to be hydroseeded (or similar). Planting of NJKHTs in 140mm pots at 10m centres along extent of zone. Mulch collar (75mm thick x 300mm radius) to be installed around each tree with 50-100mm radius separation between mulch and stem of tree. Trees to be positioned on outer edge of zone to prevent future interference with powerlines / services.

Ongoing weed mngmt, reapplication of hydroseed / turf as required and maintenance i.e. slashing / mowing throughout maintenance period to reinforce primary works. All works near powerline easement to be in accordance with Energy Queensland Work Category Specification WCS1.6.

Management Zone 6: Bushfire Protection Zone (BPZ) (Fabrication)

Entire zone to be treated in accordance with Bushfire Protection Zone (BPZ) requirements under the Bushfire Management Plan (BMP).

All trees within WWTP 10m clearing buffer to be removed. In balance BMZ, all tree species that are non-endemic to location and trees that are dead, diseased, dangerous or have a diameter <10cm at breast height to be removed. Weed mngmt to entire zone in accordance with SEQERF and RCBP to remove any self-seeding weed species.

Ongoing maintenance of BMZ to comprise slashing of shrub and grass vegetation to < 10 cm in height and ongoing treatment/removal of woody regrowth and weeds. Additional protective devices i.e. tree guards to be installed as required and in accordance with BMP.

Infill planting of native trees and groundcovers may be required where there are large gaps in canopy or soil cover. Tree plantings not to occur where they will overhang buildings or structures in the WWTP compound at maturity. Only groundcover species to be planted adjacent fire-fighter water supplies, pathways, driveways, and building. All species to be 'less flammable' species from BMP or other resources* and local provenance from mapped Pre-Clear RE 12.3.5.

Management Zone 7: Additional Earthworks Zone (Reconstruction)

Additional areas disturbed during construction to be finalised by civil contractor prior to rehabilitation works as per Management Zone 1.

Weed mngmt as per Management Zone 1 to remove any self-seeding weed species. Ongoing weed mngmt during maintenance period to reinforce primary weed removal.

Soil stabilisation to be provided through installation of aged forest mulch (100mm thick) at elevated locations not prone to inundation or washout, and either a highly durable natural fibre matting, or combination of aged forest mulch (100mm thick) and natural fibre netting at locations prone to inundation or washout. Additional erosion-control measures / protective devices i.e. coir logs or tree guards to be installed as required.

Tubestock planting of trees, shrubs and groundcovers throughout zone at rates of 1:10, 1:5 and 2:1 plants per square metre respectively unless the earthworks occur within another zone that has greater / different planting requirements. Plant species to be selected according to site conditions and the pre-clear Regional Ecosystem at location.

NOTE: ALL SOIL STABILISATION MEASURES / PROTECTIVE DEVICES TO BE INSTALLED AS PER MANUFACTURER'S RECOMMENDATIONS.

NOTE: ALL MANAGEMENT ZONES OVERLAPPING BMZ TO COMPLY WITH REQUIREMENTS OF BMZ.

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REFERENCES:
Engineering (KN Group / Stantec 2020)

AMENDMENTS:

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PROJECT:
38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 3/RP223470
1/SL3427, 254/S31102)

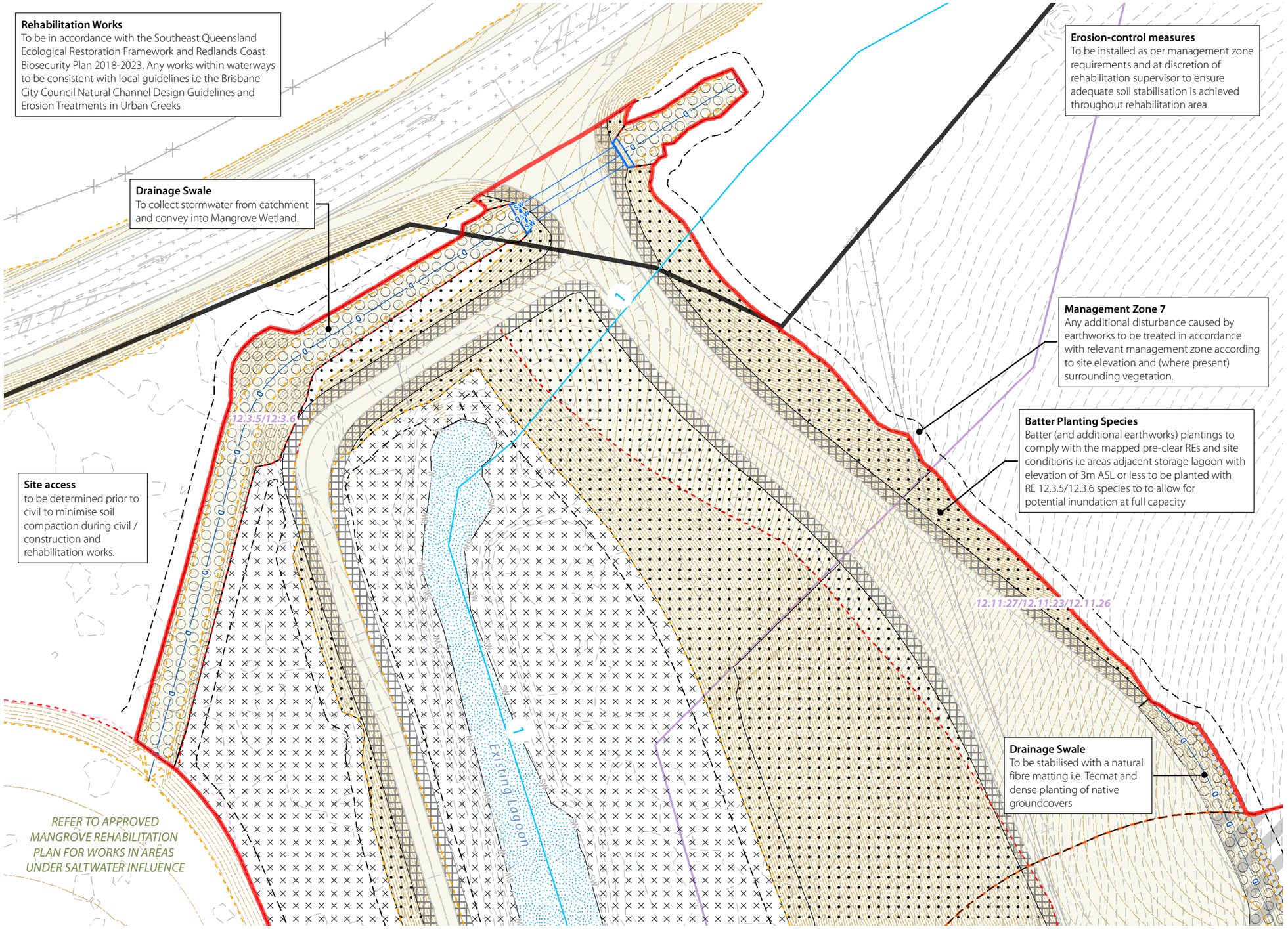
environmental management

PLAN OF:
Rehabilitation Plan
Management Zones

DATE:	10/11/2020	CHECKED:	JB/NC
CLIENT REF.:	8868	DRAWN:	MC
DRAWING No.:	8868 E 04 CRP D		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - DETAIL SHEET 05



LEGEND

- **Zone 1** RE 12.3.5 / Storage lagoon
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- **Zone 4** Landscape / Turf
- **Zone 5** Scattered NJKHT
- **Zone 6** Bushfire Protection Zone
- **Zone 7** Additional earthworks buffer (indicative)
- Existing freshwater lagoon
- Earthworks extent
- Pre-clearance Regional Ecosystem boundary
- QLD DCDB
- Site DCDB
- Rehabilitation area
- Indicative WWTP design
- Road design
- WW Wastewater services
- W W Water services
- SW SW Stormwater services
- Drainage channel
- Bushfire zone
- STP 10m clearing zone
- Service mains works area
- Rock wall
- Batter bottom
- Batter top
- Stantec batters
- Water tech batters
- Design contours
- Existing contours
- Survey / existing

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REFERENCES:
Engineering drawings (KN Group / Stantec 2020)
Layout drawings (SHG 2020)

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D	10/11/2020	STP updates	JB/NC

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PROJECT:
38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 3/RP223470
1/SL3427, 254/S31102)

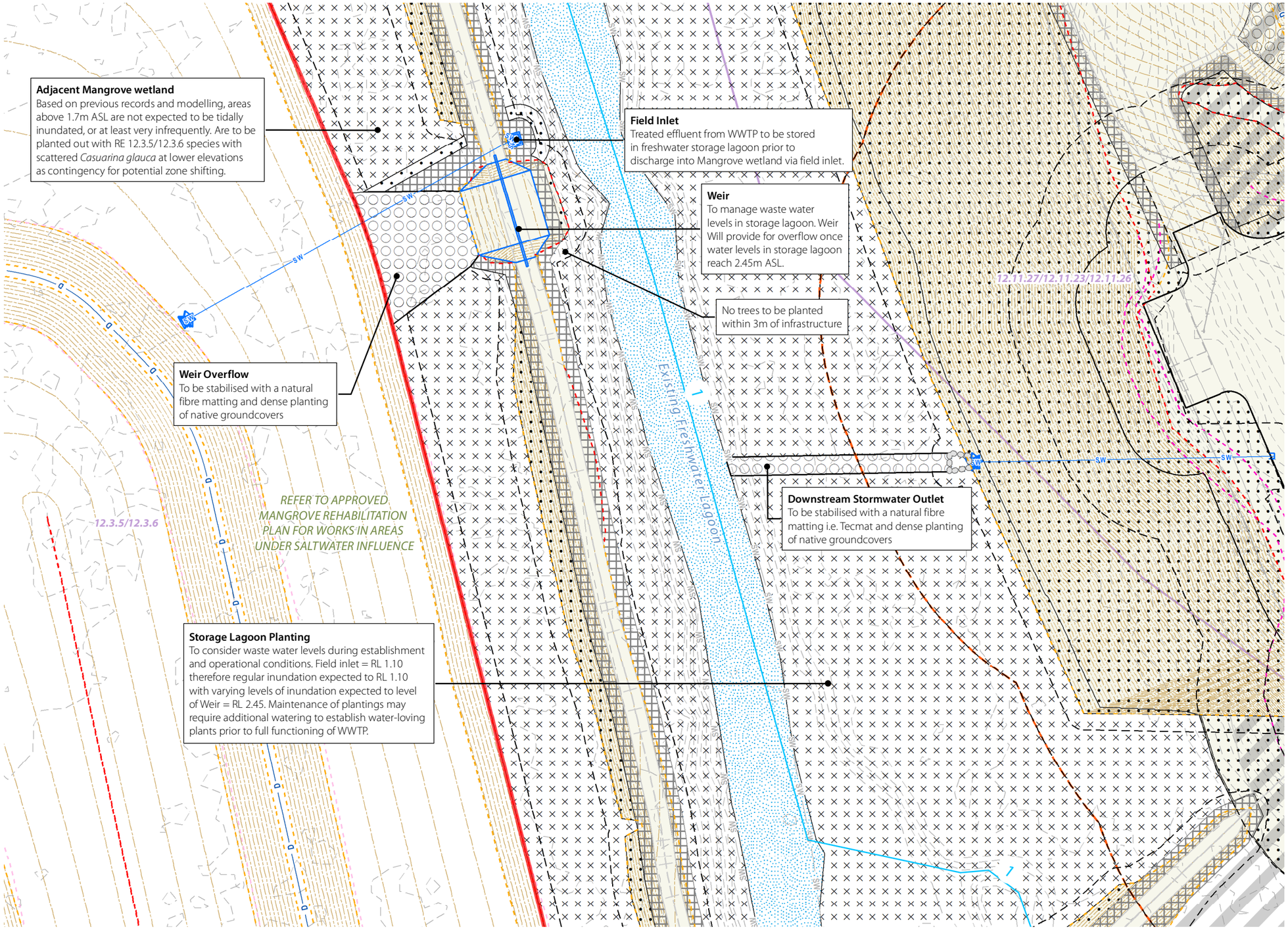
environmental management

PLAN OF:
Rehabilitation Plan
Detail Sheet 05

DATE:	10/11/2020	CHECKED:	JB/NC
CLIENT REF.:	8868	DRAWN:	MC
DRAWING No.:	8868 E 05 CRP A		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - DETAIL SHEET 06



LEGEND

- **Zone 1** RE 12.3.5 / Storage lagoon
- **Zone 2** Drainage line / Stormwater outlet / Drain
- **Zone 3** Earthworks batters
- **Zone 4** Landscape / Turf
- **Zone 5** Scattered NJKHT
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- Survey / existing

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Layout drawings (SHG 2020)

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PROJECT:

38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 3/RP223470
1/SL3427, 254/S31102)

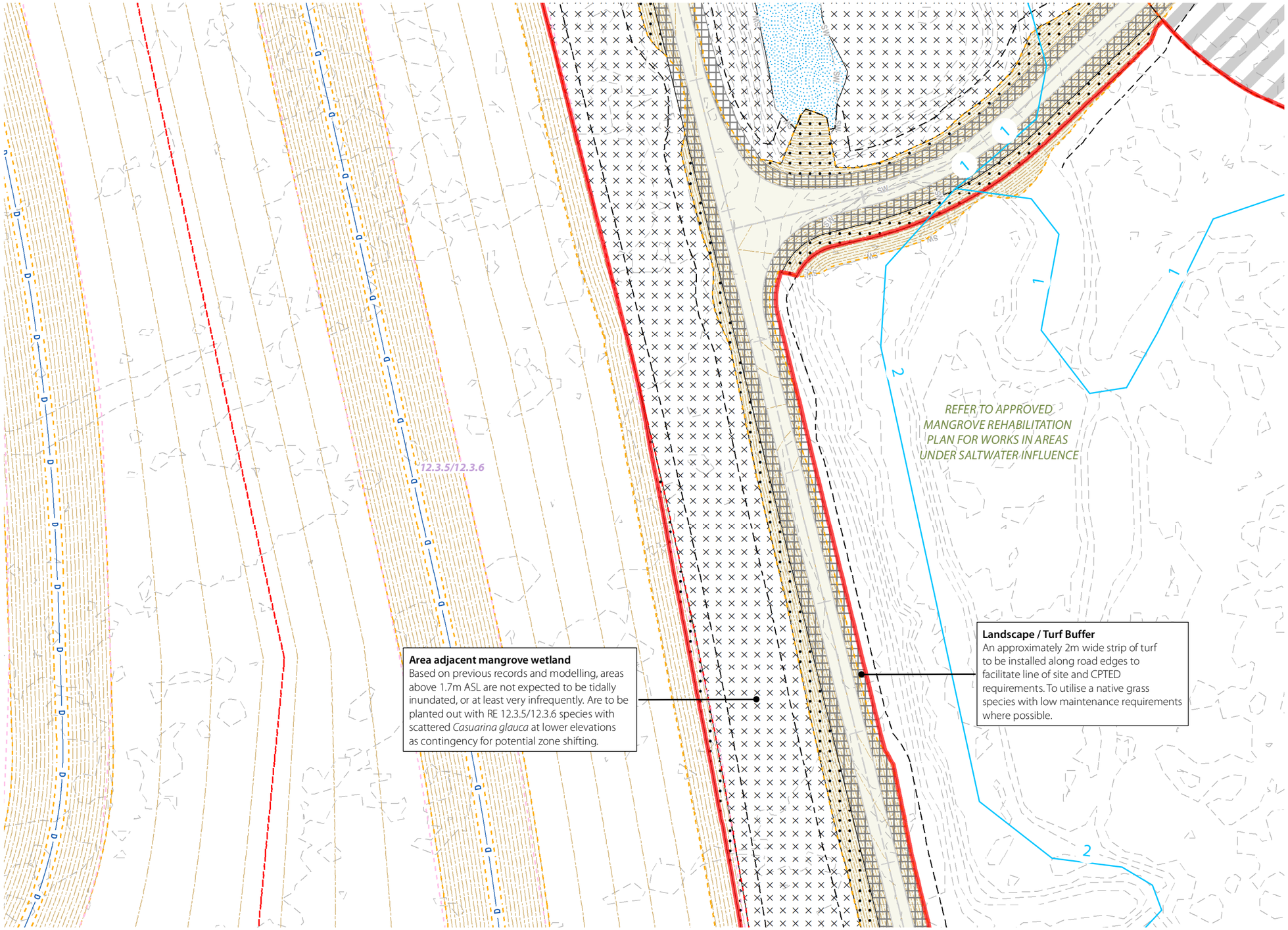
environmental management

PLAN OF:
Rehabilitation Plan
Detail Sheet 06

DATE:	10/11/2020	CHECKED:	JB/NC
CLIENT REF.:	8868	DRAWN:	MC
DRAWING No.:	8868 E 06 CRP A		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - DETAIL SHEET 07



LEGEND

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PROJECT:
38 LONGLAND ROAD
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(2/RP223470, 3/RP223470
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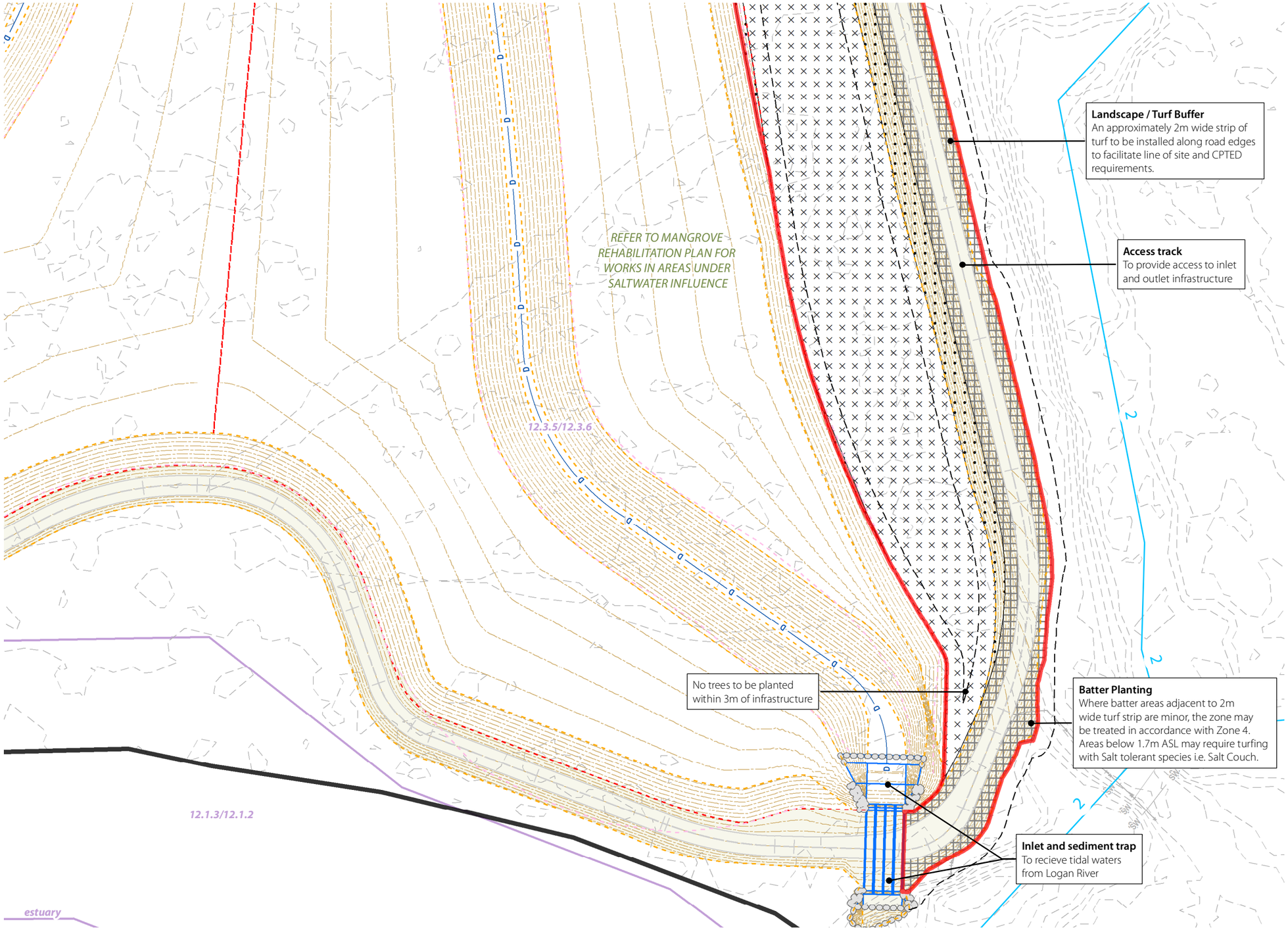
environmental management

PLAN OF:
Rehabilitation Plan
Detail Sheet 07

DATE:	10/11/2020	CHECKED:	JB/NC
CLIENT REF:	8868	DRAWN:	MC
DRAWING No.:	8868 E 07 CRP A		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - DETAIL SHEET 08



LEGEND

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PROJECT:

38 LONGLAND ROAD
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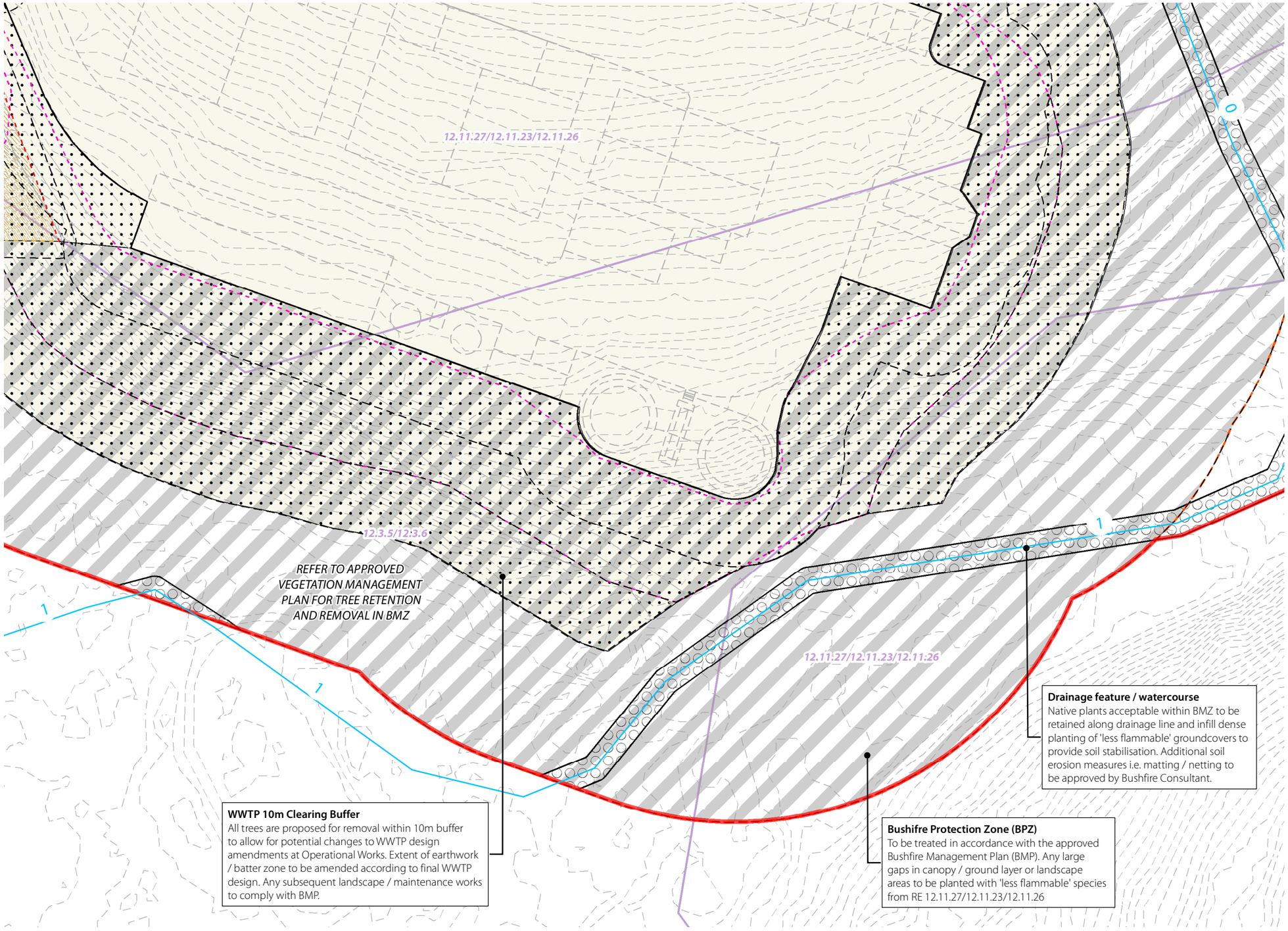
environmental management

PLAN OF:
Rehabilitation Plan
Detail Sheet 08

DATE:	10/11/2020	CHECKED:	JB/NC
CLIENT REF:	8868	DRAWN:	MC
DRAWING No.:	8868 E 08 CRP A		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - DETAIL SHEET 09



LEGEND

- **Zone 1** RE 12.3.5 / Storage lagoon
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Layout drawings (SHG 2020)

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PROJECT:

38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 3/RP223470
1/SL3427, 254/S31102)

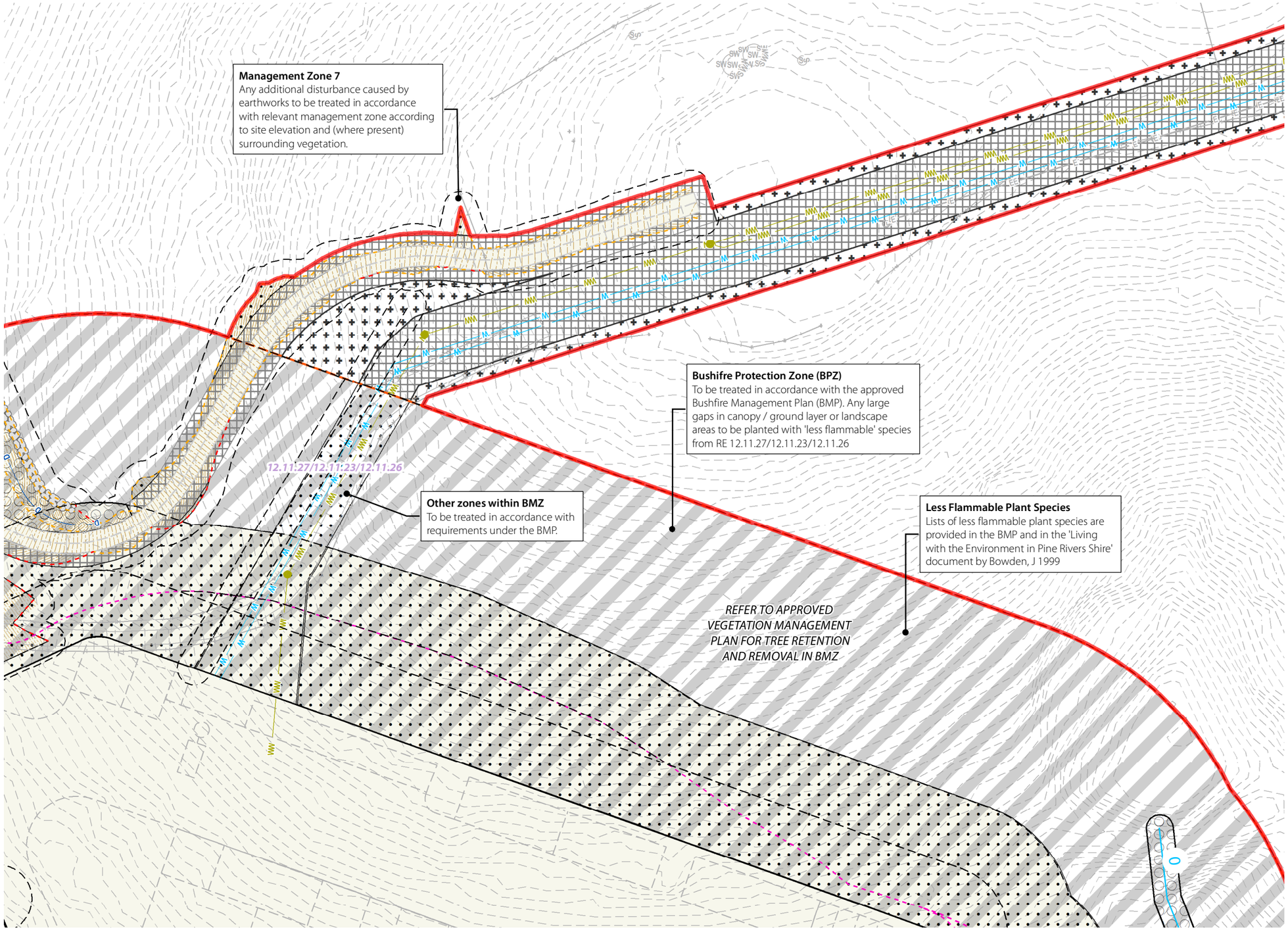
environmental management

PLAN OF:
Rehabilitation Plan
Detail Sheet 09

DATE:	10/11/2020	CHECKED:	JB/NC
CLIENT REF.:	8868	DRAWN:	MC
DRAWING No.:	8868 E 09 CRP A		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - DETAIL SHEET 10



LEGEND

- **Zone 1** RE 12.3.5 / Storage lagoon
- **Zone 2** Drainage line / Stormwater outlet / Drain
- **Zone 3** Earthworks batters
- **Zone 4** Landscape / Turf
- **Zone 5** Scattered NJKHT
- **Zone 6** Bushfire Protection Zone
- **Zone 7** Additional earthworks buffer (indicative)
- Existing freshwater lagoon
- Earthworks extent
- Pre-clearance Regional Ecosystem boundary
- QLD DCDB
- Site DCDB
- Rehabilitation area
- Indicative WWTP design
- Road design
- Wastewater services
- Water services
- Stormwater services
- Drainage channel
- Bushfire zone
- STP 10m clearing zone
- Service mains works area
- Rock wall
- Batter bottom
- Batter top
- Stantec batters
- Water tech batters
- Design contours
- Existing contours
- Survey / existing

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REFERENCES:
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Layout drawings (SHG 2020)

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PROJECT:
38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 3/RP223470
1/SL3427, 254/S31102)

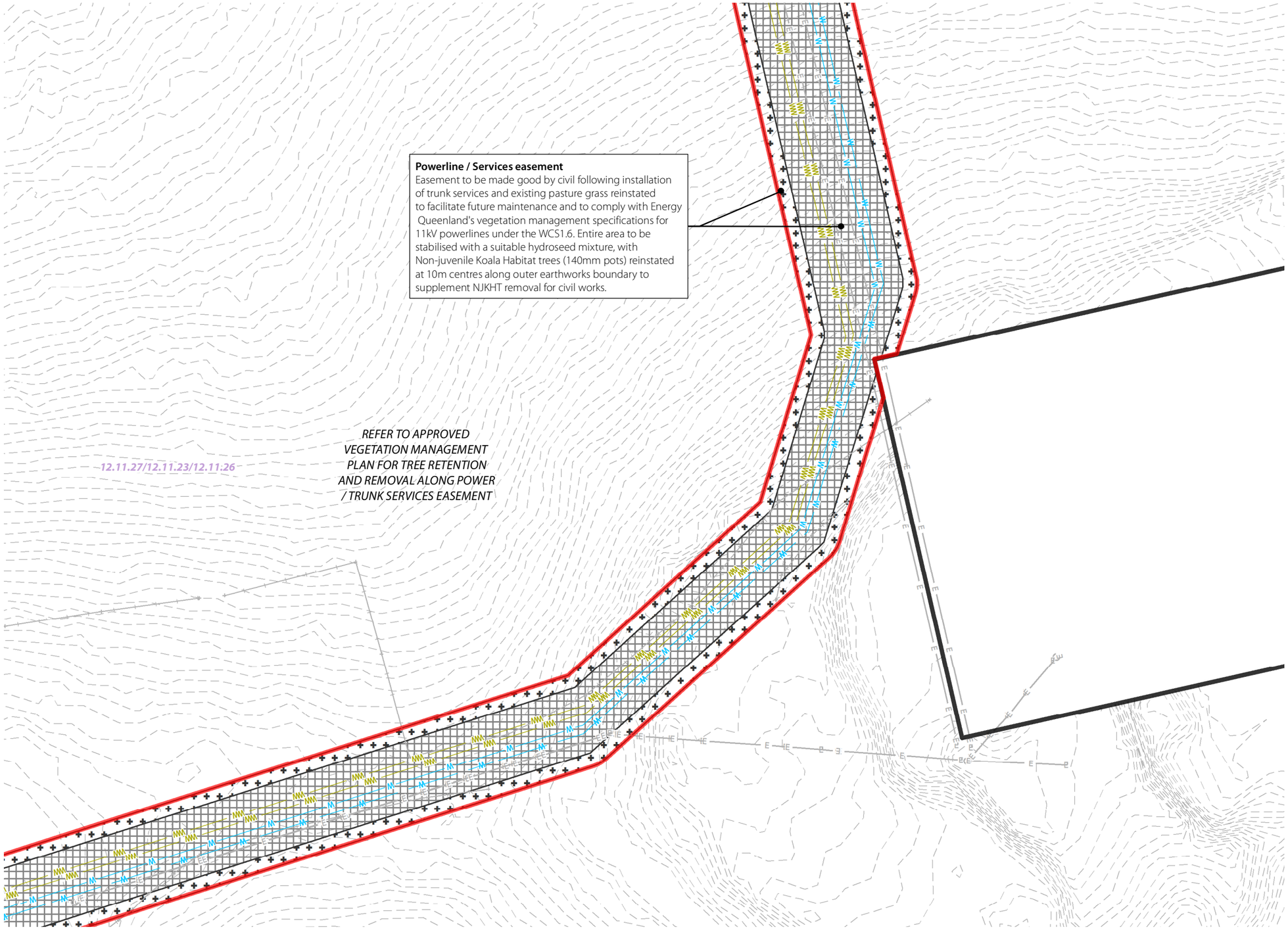
environmental management

PLAN OF:
Rehabilitation Plan
Detail Sheet 10

DATE:	10/11/2020	CHECKED:	JB/NC
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SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - DETAIL SHEET 11



LEGEND

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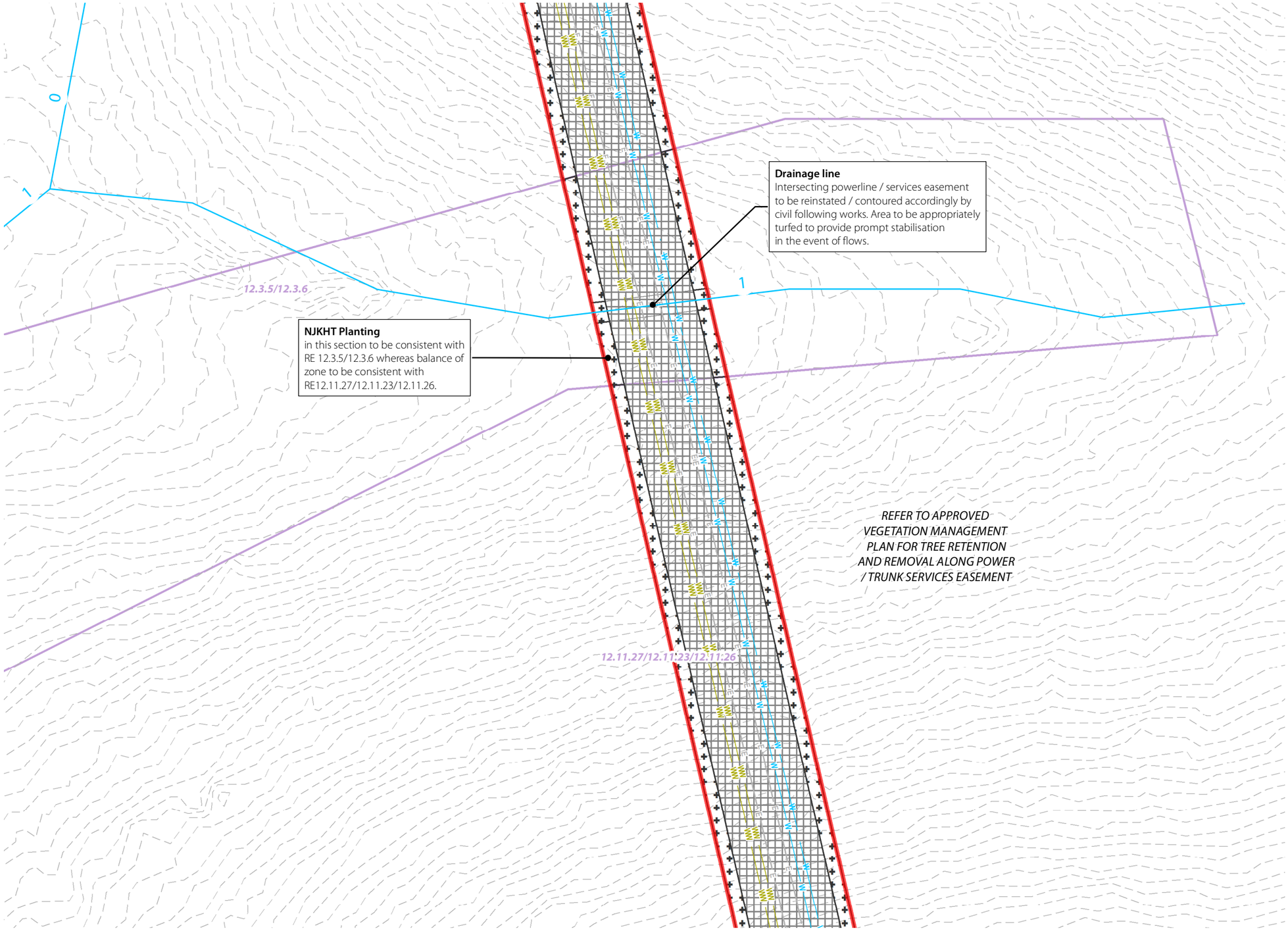
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PLAN OF:
Rehabilitation Plan
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SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - DETAIL SHEET 12



LEGEND

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PROJECT:

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environmental management

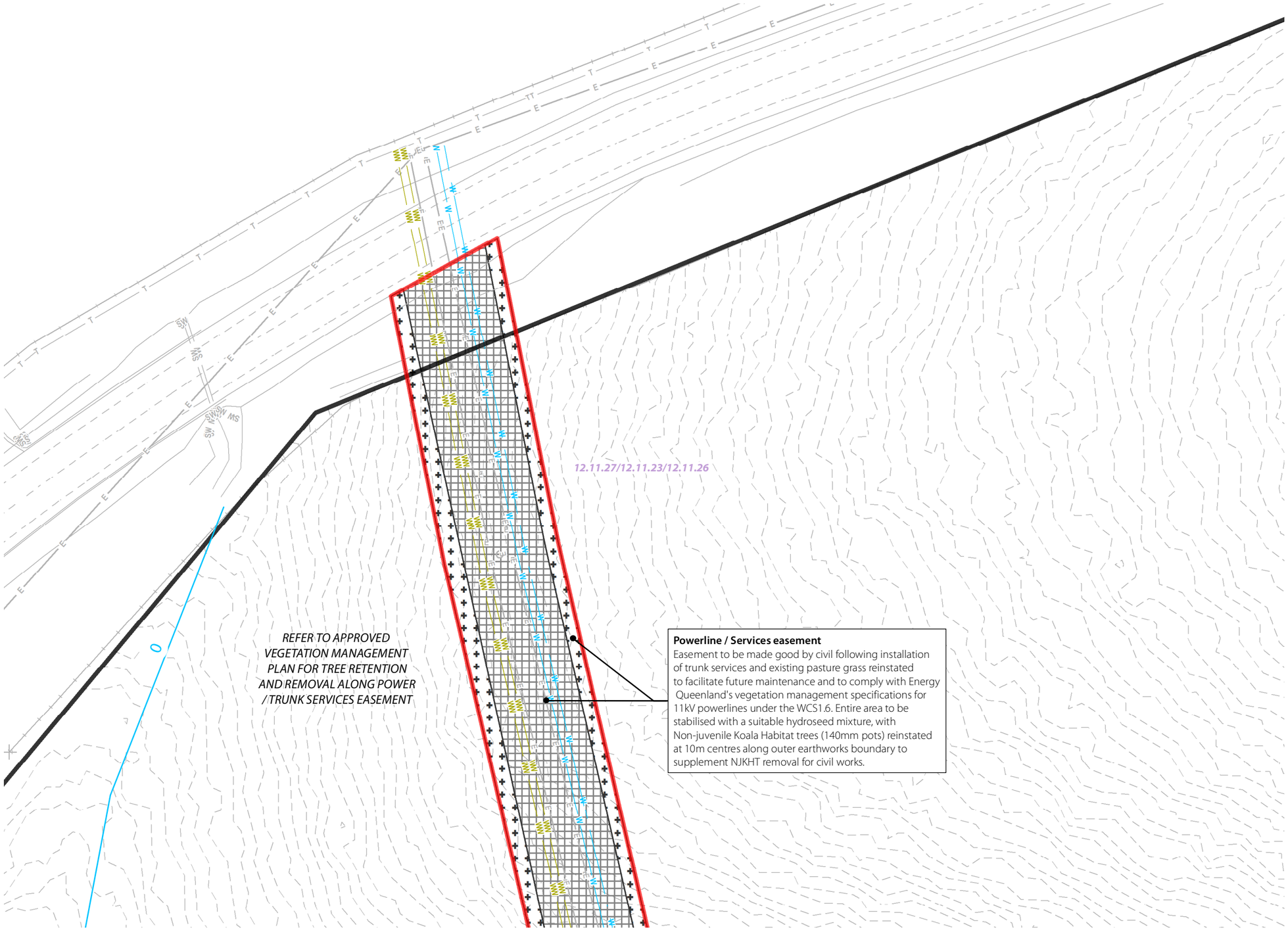
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Rehabilitation Plan
Detail Sheet 12

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SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - DETAIL SHEET 13



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PROJECT:
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environmental management

PLAN OF:
Rehabilitation Plan
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SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - SITE WORKS / WEED NOTES

METHODOLOGY – SITE WORKS

Following resolution of the site analysis and management areas as part of rehabilitation design, prioritising site works should be considered. Prior to site works commencing, the site should be secured from degrading impacts such as grazing by stock, unauthorised access and rubbish. Some factors that may require immediate attention include:

- The presence of highly invasive weed species which may disperse further prior to substantial site works commencing
- The presence of weed species which may have a long term impact on ecological communities such as exotic and weed varieties of vines
- Flammable materials (including weed thickets, grasses and vines)
- Damaging and easy access by 4WD, motorbikes and pedestrians into core retained vegetation and ecological restoration areas. This may require installation of temporary fencing if deemed appropriate

Site works can be typically broken down into the following categories:

- Primary Works
- Follow-up Works
- Maintenance Works

Primary Works

Primary works or initial works within the site or a section of the site will commonly involve a sequence of activities such as the control of all groundcover weeds, woody weeds in the understorey and exotic vines prior to the control of weed trees. Primary work has the effect of creating a large degree of disturbance which will stimulate the germination of native and exotic species. Therefore, continuing works should be scheduled shortly after the initial visit to allow for timely control of the newly regenerating weeds.

Highly invasive weeds, such as the Restricted Invasive Plants listed under the *Biosecurity Act 2014*, should be treated as a priority during primary works to alleviate competition on native flora species and inhibit spread into newly disturbed areas. For example, canopy smothering vines such as Cat's Claw Creeper can have a detrimental impact on native canopy trees and should be prioritised over less invasive herbs such as Blue Billy Goat Weed. Some weeds will also need to be treated in stages i.e. where the weed provides protection and habitat for native fauna or where it is providing bank stabilisation. For example, where Lantana is providing the only habitat for small birds, it should be removed in phases as native shrub habitat establishes.

Techniques used during primary work commonly involve spot spray, cut-scrape paint, cut-paint, scrape-paint, roll-hang and over spraying (source: SEQERF). Refer to Weed Management notes for additional details.

Due to the potential negative impacts on aquatic / semi-aquatic fauna at this site—chemical control should be limited to locations away from waterways during dry periods only, and outside of period between egg laying and dispersal of juvenile frogs.

Following completion of weed management, rehabilitation (such as assisted natural regeneration, construction and fabrication planting) can occur in areas unaffected by weed management activities or areas that primary weed management activities have concluded. Refer to Rehabilitation Works notes for additional details. At the end of primary work, the zone will have been comprehensively and systematically worked, ready for follow-up works.

Follow-up Works

At intervals, which will vary according to the type of weed impacting the site and growing conditions, follow-up work will be necessary. This generally involves the spot-spraying of newly germinating weeds and resprouting sections of woody weeds and vines. It is at this stage that observational visits should be made to the site to determine what progress the vegetation is making, and decide when to implement further follow-up work. A site that receives badly-timed, too frequent or too little follow-up will rapidly experience setbacks, as weed propagules will quickly become established in the newly disturbed areas. Germinating native seedlings may be swamped by weeds or damaged by inexperienced operators thereby exhausting the seed bank. Unless adequate follow-up can be ensured when planning restoration works, there is little point in commencing primary work, as time and resources are consumed with no substantial gain achieved (source: SEQERF).

Maintenance Works

By the maintenance stage, the vegetation community is at a point where native plant species are germinating and establishing, and canopy formation is occurring. Weed density is starting to decrease as the native plants which have been encouraged during the previous restoration works are able to out-compete the weeds. One of the fundamental principles of ecological restoration is that it attempts to create or re-establish an ecosystem that is self-sustaining. Therefore, it is the underlying goal that maintenance will eventually be decreased to a minimum. While this is not always possible, due to factors such as the continual reintroduction of weed propagules to the site from nearby residential areas; unfavourable seasons or weather event; persistent weed species; or global influences such as the enhanced greenhouse effect, it should always be strived for (source: SEQERF). Maintenance works may include minor ongoing weed management and infill planting depending on site conditions.

METHODOLOGY – WEED NOTES

Weed management typically comprises a major part of rehabilitation site works. Weed management provides the basis of aiding natural regeneration and assisted natural regeneration. It also forms part of the preliminary work required for reconstruction and fabrication scopes.

Weed Management is to be undertaken in accordance with the SEQERF and Primary, Follow-up and Maintenance works notes above. Weed management shall encompass all species declared at the commonwealth, state and local level, and any weeds that appear to be invasive at the site.

A total of forty-five (45) weed species were identified on site during vegetation assessments. Eleven (11) of these are classified as Restricted Invasive Plants under the Biosecurity Act 2014 and are listed in Appendix A. Four (4) of the Restricted Invasive Plant species are also classified as Weeds of National Significance (WoNS) that have been selected nation-wide based on their level of invasiveness, potential for spread and environmental, social and economic impacts.

Critical skills for Weed Management include:

- Knowledge of relevant legislation
- Plant Identification skills
- Knowledge of different weed management techniques

Knowledge of Relevant Legislation

It is expected contractors have a depth of knowledge of relevant legislation to complete site rehabilitation works. This may include occupational Health and Safety laws as well as environmental and heritage protection legislation. Bush regenerators must comply with the requirements of the Workplace Health and Safety Act 2011 or, when working on Commonwealth lands, the Commonwealth's Occupational Health and Safety (Commonwealth Employment) Act 1991. Contractors should also obtain all relevant permits required under State and Commonwealth legislation (e.g.Nature Conservation Act 1992, Fisheries Act 1994, Vegetation Management Act 1999, Biosecurity Act 2014). Contractors must also be aware of and adhere to cultural heritage protection obligations under the Aboriginal Cultural Heritage Act 2003 and where chemicals are in use, the Agricultural Chemicals Distribution Control Act 1966.

In addition to the above, contractors should also be familiar with local government body requirements (e.g. Pest Management Plans, Local Codes, Policies and Guidelines) and Classifications of weeds. Refer to adjacent schedules for classification of weeds under the Biosecurity Act 2014).

RESTRICTED MATTERS (*BIOSECURITY ACT 2014*)	
Category	**Description**
1	must be reported to an inspector within 24 hours if it is present in, or on, something in your possession or under your control or at a place where you are the occupier, unless an appropriately authorised officer has already been advised or you possess a permit for the restricted matter. Includes red imported fire ants, electric ants, Asian honey bees, and certain animal diseases, aquatic diseases and pathogens.
2	must be reported to an inspector within 24 hours if it is present in, or on, something in your possession or under your control or at a place where you are the occupier, unless an appropriately authorised officer has already been advised or you possess a permit for the restricted matter. includes certain noxious fish, weeds and pest animals
3	You must not distribute this restricted matter. It must not be given as a gift, sold, traded or released into the environment unless the distribution or disposal is authorised in a regulation or under a permit. Deliberate human distribution or disposal contrary to the legislation is a key source of spread into other areas. includes weeds, pest animals and noxious fish
4	You must not move this restricted matter to ensure that it does not spread into other areas of the state. includes specific weeds, pest animals and noxious fish
5	You must not possess or keep this restricted matter under your control. These pests have a high risk of negatively impacting on the environment. You may only keep this restricted matter under a permit of the *Biosecurity Act 2014* or another Act. includes weeds, pest animals and noxious fish
6	You must not feed this category of restricted matter. Feeding this restricted matter may cause their numbers to increase and negatively impact the economy or the environment. Feeding for the purpose of preparing for or undertaking a control program is exempted. Includes invasive animals such as feral deer, foxes, rabbits and wild dogs and noxious fish such as carp, gambusia and tilapia.
7	If you have these noxious fish in your possession you must kill the restricted matter and dispose of the carcass by burying the whole carcass in the ground above the high tide water mark or placing it in a waste disposal receptacle. Includes noxious fish such as carp, weatherloach, climbing perch and gambusia

Plant Identification Skills

Both native and weed species should be identified prior to primary weed removal works and ongoing throughout the follow-up and maintenance periods. This is to maximise natural regeneration and reducing likelihood of accidental weed spraying to native vegetation. Regenerating species to be treated and maintained in a similar manner to newly planted revegetation tubestock. If contractor is unsure of species, advise should be sought by botanist, specialist contractor or confirmed with Queensland Herbarium. Refer to indicative Weed Treatment schedules derived from Queensland Herbarium for an indication of weed species and treatments.

Knowledge of Different Weed Management Techniques

A range of weed management techniques are available to combat varying weed species and scenarios. Refer to adjacent schedules and Appendix A for an indication of weed management techniques.

Due to the potential negative impacts on aquatic / semi-aquatic fauna at this site—chemical control should be limited to locations away from waterbodies, during dry periods only, and outside of period between egg laying and dispersal of juvenile frogs. It is also important that erosion problems are not created by excessive removal of weed growth.

WEED MANAGEMENT TECHNIQUES	
METHOD	**DESCRIPTION**
Herbicide	**The herbicide weed control techniques described below provide a range of proven methods that can be used on a restoration site.**
Cut - Scrape-Paint	Cut the stem of the plant close to the ground (approximately 1-2cm) ensuring that soil does not come in contact with the cut surface. The cut can be made at a slight angle in order to increase the surface area that is exposed to the chemical. Apply herbicide immediately to the cut stump using poison pot and brush or dripper bottle. Using a knife, scrape the sides of the stump thoroughly to expose the green tissue. Apply herbicide to the scraped stump. The chemical must be applied within 10 seconds of the cut or scrape being made in order for it to be fully effective.
Cut - Paint	Cut the stem of the plant close to ground level. Apply herbicide to the cut stump using poison pot and brush or dripper bottle. This method is best suited to easy-to-treat weeds such as small-leaved privet (Ligustrum sinense), provided that the diameter of the stem at ground level is less than approximately three centimetres. If a glyphosate-/ metsulfuron methyl herbicide mix is being used in the poison pot, a greater range of weeds can be controlled using this method e.g. Easter cassia.
Scrape - Paint	Scrape as much of the stem as possible (one side of the stem) using a knife and apply herbicide to the scrape. Leave a small section of the vine unscraped, and then twist the vine so that the next scrape is made on the opposite side of the stem to the preceding scrape. Continue along the length of the vine, scraping and painting as much of the stem as possible, with scraping to be concentrated along the thicker stems close to the root of the plant. This is the best method to use for madeira vine, as it allows the chemical to translocate to the underground storage organs and aerial tubers which may be hanging in large clusters above head height. This avoids the potential problem of tubers from cut stems left hanging in the trees from dropping to the ground and sprouting. When scraping madeira vine stems a deep scrape is advisable – scrape right through to the fibrous, stringy section of the stem, taking care not to sever the vine. This method is also suitable for treatment of ochna.
Over-spraying	Over-spraying involves the use of knapsacks or power sprayers to treat large expanses of weed such as lantana thickets. The foliage must be covered with herbicide but not to the point of running off the plant. The dead plants remain in place and can be cut down at a later stage. Prior to over-spraying, any weeds that are growing closely around established native plants must be hand removed or treated by cut-scrape-paint.
oll-hang	Vines such as mile-a-minute (Ipomoea cairica) which produce long stolons extending many metres along the surface of the ground, are suited to the roll-hang method. Locate the base of the plant and carefully pull up the runners and roll them up. The resulting roll of vine is then hung in the fork of a tree to dry out as if it is left on the ground it is likely to re-shoot. Where runners are climbing up into a tree they are cut off at head height prior to the runner being rolled up – there is no need to pull cut vines down from trees as this action is likely to damage the tree. The base of the vine is treated using the cutscrape-paint method.

WEED MANAGEMENT TECHNIQUES	
METHOD	**DESCRIPTION**
Gouge-paint	This method applies to plant species that have a fleshy underground storage organ, such as the large tuber that is often found at the base of madeira vine. It is also particularly appropriate for the treatment of climbing asparagus (Protasparagus plumosus). If using this technique on climbing asparagus, first cut the stems that are growing into the canopy at head height and also at the base. The fleshy rhizome can then be gouged, or alternatively in the case of climbing asparagus, it may be struck several times firmly with the head of a pair of loppers, allowing the brown outer covering of the crown to peel away exposing the white fleshy inner section of the rhizome for application of herbicide. Gouge out sections of the fleshy base with a knife and apply herbicide using a paint pot and brush or dripper bottle within 10 seconds.
Basal Barking	This method involves mixing an oil-soluble herbicide in diesel/kerosene and painting or spraying the full circumference of the trunk or stem of the plant from ground level to a height of approximately 45cm. Basal bark application is suitable for thin-barked woody weeds including saplings, regrowth and multi-stemmed shrubs. The method will usually result in the mortality of difficult-to-control woody weeds at any time of the year, provided the bark is not wet or too thick to enable the herbicide to penetrate. The method should not be used in wet weather, adjacent to waterways or in areas where native trees and shrubs are located. The use should be restricted to situations where a weed is particularly difficult to control e.g. cherry guava and where other methods have been unsuccessful.
Splatter Gun	This small gas-powered injector kit is fitted into a knapsack for easy carrying and delivers large droplets in a stream over the weed. The gun is used to deliver a concentrated herbicide (glyphosate or metsulfuron methyl) across large dense expanses of weed. The method is used for species such as lantana (ratio of 1:9 of glyphosate:water). Splatter gun involves spraying strips at one to two metre intervals over the thicket. The herbicide is then translocated throughout the entire plant. The method does not require the whole plant to be covered as in over-spray.
Spot-spraying	A knapsack filled with an appropriate herbicide mix is used by the operator to selectively control environmental weeds. A keen eye and an ability to distinguish between the native and weed species likely to be present, especially at seedling stage, is essential. Marker dye is added to the chemical mix to allow the operator to see what has already been sprayed, thus covering the ground weeds comprehensively and thoroughly Glyphosate and metsulfuron methyl are the main herbicides used for spot-spraying in ecological restoration, together with the addition of a penetrant and/or surfactant and marker dye.
Stem Injection	Large woody weeds such as camphor laurel, coral trees (Erythrina spp, Privet Ligustrum spp) and umbrella trees are generally treated by stem-injection. Holes are drilled at regular intervals around the base of the tree and exposed roots using a drill. A tree injection syringe attached to a small capacity knapsack is used to fill the holes with the herbicide. Stem-injection of trees can also be undertaken using a hatchet to create cuts in a 'brickwork pattern' in trunks of trees for the application of herbicide (known as tree frilling). Frilling is more labour intensive than drilling. The greatest benefit of steminjection is that the trees can be left standing in situ as they die, provided there is no risk to humans or infrastructure from falling limbs. This creates convenient roosts for birds and other animals, and prevents the formation of large amounts of debris on the ground and damage to understorey plants which would result if the trees were to be cut down using a chainsaw.
Wick Wiping	Wick wipers can be manually used with a sponge or wick applicator, attached to a container filled with herbicide or as an attachment towed by a tractor. The manual method can be used to selectively apply herbicide to the leaves of weeds growing in sensitive situations. The hand held container can leak and generally spot spraying would be recommended. The use of a tractor drawn wick wiper is used to control taller growing species such as introduced grasses and to encourage the growth of lower growing species. This method could be used in preparation for planting.
Mechanical	**Mechanical weed control involves the use of powered and non-powered equipment such as brushcutters, chainsaws, slashers, shovels, pruners, saws, etc. These methods are best used in situations where there is a large, uninterrupted stand of weeds.**
Dig and Bag	Dig and remove tuberous/ rhizomatous root systems. Remove roots or whole plant in hard/ compacted soils. Place in suitable container and remove from site, dispose of by deep burial, burn or burial at a land fill, must not place declared weed species in recycling (mulch).
Hand-Pull	Remove totally from ground by hand (human). Perform when soil is moist. Applicable to small infestations or areas of environmental sensitivity (including sensitive watercrouses, when frogs are breeding, or presence of threatened species).
General Mechanical	May involve use of machinery (e.g. brushcutter, chainsaw, slasher, dozer, excavator). Suitable for lage infestations and weed trees. Initially cost-effective, but requires immediate revegetation of site or matting/ mulch application and extensive maintenance periods. Generates excessive soil and vegetation disturbance.

Note: Table adapted from a table in SEQERF

Weed management techniques for the eleven (11) Restricted Invasive Plants have been adapted from the Business Queensland website and are provided in Appendix A.

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REFERENCES:
South East Queensland Ecological Restoration Framework (2012)
Weeds of National Significance(https://www.environment.gov.au/biodiversity/invasive/weeds/weeds/lists/wons.html)

AMENDMENTS:

Issue	Date	Description	Checked
A	23/07/2020	Preliminary	TL/KG/NC
B	19/08/2020	DAF updates	TL/KG/NC
C	29/09/2020	DAF updates	TL/KG/NC
D	10/11/2020	STP updates	JB/NC

PROJECT:
38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 3/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF: Rehabilitation Plan Notes

DATE:	10/11/2020	CHECKED:	JB/NC
CLIENT REF:	8868	DRAWN:	MC
DRAWING No.:	8868 E 11 CRP D		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - PLANTING NOTES

METHODOLOGY – PLANTING NOTES

Primary weed management works, areas requiring infill planting (assisted natural regeneration), and larger scale planting (reconstruction and fabrication) can be undertaken. Prior to installation, the following items should be considered:

- Species selection
- Sourcing plant material
- Timing of planting
- Site preparation
- Planting density
- Planting installation

Species Selection

Species selection is critical in achieving the desired ecological restoration outcomes for rehabilitation sites. Planting is typically derived from:

- Local Regional Ecosystem (RE) descriptions.
- Observed site native vegetation.
- Bioretention guideline requirements.
- Climatic and weather conditions observed on site (frost, salt-spray, etc.
- 'Pioneer' species are useful in site stabilisation and encouraging native regeneration.
- Utilising flowering and fruiting species are useful to attract wildlife and result in introduction of seeds.
- Diverse vegetation layers (trees, shrubs, groundcovers)
- Species availability from seed propagation and or local nurseries

Refer to plant schedule for species and planting densities.

Sourcing Plant Material

There are a number of options for sourcing plant material for revegetation purposes. Propagation from site seed is a good outcome however is often limited by required timing of works. Sourcing planting from local nurseries is the commonly chosen option and has the following benefits:

- Awareness of genetic considerations when collecting seed.
- Experience with breaking dormancy mechanisms in hard to germinate seeds.
- Highly successful propagation techniques.
- Ability to provide high quality stock to order
- Draw on industry resources.

Timing of Planting

The timing of planting should ideally be aligned with the wet season in SEQ (summer and autumn). This minimises the need for intensive watering to establishment planting. Planting between February to May is the most beneficial as it also seeks to avoid intense heat periods of summer. Despite this, it is understood planting may occur at various times within rehabilitation areas due to development timing needs.

Site Preparation

Site or planting preparation includes:

- Fencing to exclude grazing animals and people (if required)
- Pre-spraying of exotic grasses and other weeds to planting areas
- Consideration of source of water for new planting (access tracks, temporary irrigation)
- Arranging delivery of mulch, jute netting and treeguards (if required)
- Treatment of heavily compacted soils by ripping and or application of gypsum
- Soil amelioration as required

Planting Density

Plant density is calculated on a zone by zone basis. This allows planting to cater for various requirements including standard revegetation, infill only requirements such as canopy trees at low densities, as well as dense bioretention plantings as per Bioretention Technical Guidelines. Refer to plant schedule for species and planting densities.

Planting Installation

The following outlines the preferred installation methodology for revegetation works within the rehabilitation areas. It has been designed to maximise plant establishment success rates and minimize plant mortality. Revegetation works shall be either undertaken or directly supervised by an experienced and qualified contractor. All works shall be in accordance with the provisions of this CRP, and local government policies and Australian Standards.

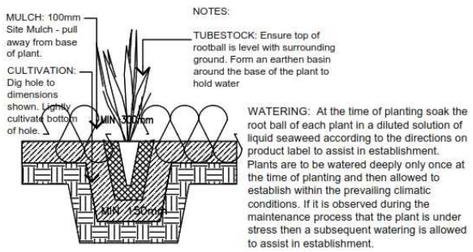
Plant installation methods shall include:

- Plants are to be vigorous, well established, hardened off, consistent with species or variety, free from disease and insect pests, with large root systems and no evidence of having been restricted or damaged. The landscape coordinator has the right to inspect and reject stock prior to planting
- Plants are to be planted immediately after delivery to the planting site.
- Planting is to be undertaken in accordance with the planting module contained within this drawing sheet.
- Excavate planting medium to a depth suitable for the installation of tube or pot specimens. In areas where planting substrate is deemed to be very poor (compacted, nutrient deficient, hydrophobic etc.) and above areas of potential frequent inundation and waterflow, topsoil may be used.
- Pre-water plant hole, if soil is dry, to decrease root stress upon planting and assess the infiltration of water through the soil.
- Incorporate into the planting substrate the appropriate quantity of prepared water crystals or other
- Suitable hydrating product such as Hortex 'Rainsaver' or 'Moisturaid'.
- Place plant into hole and backfill ensuring that the plant is upright and the stem is not covered in any less than 10mm or anymore than 20mm of planting medium.
- Plants are to be watered thoroughly immediately after planting (ensure deep irrigation) and thereafter as required during the construction phase of the development depending on climatic conditions. Creation of a concave hollow around the base of each plant will aid water infiltration to the plant roots.
- A complete, slow release fertiliser is recommended, and is to be administered appropriately during
- planting. Topdressing with slow release fertiliser is preferred to avoid toxic levels of fertiliser
- accumulating in the plant hole around the plant roots.
- To ensure successful establishment, all planting surfaces must be covered in:
    - a 100mm layer of high quality weed-free composted chip mulch (site mulch)- Note: to avoid possiblestem rot in some 'drier' species ensure mulch is 'dished' and not covering plant stem by more than 20mm. Where available, mulch material to be sourced from cleared vegetation material if adequately seasoned, or
    - Suitable individual anchored natural fibre weed mat (jute netting); or
- A long term slow release fertiliser, such as Nutricote or similar product should be used for all plantings after initial plant establishment.
- A minimum 90% survival rate should be achieved.

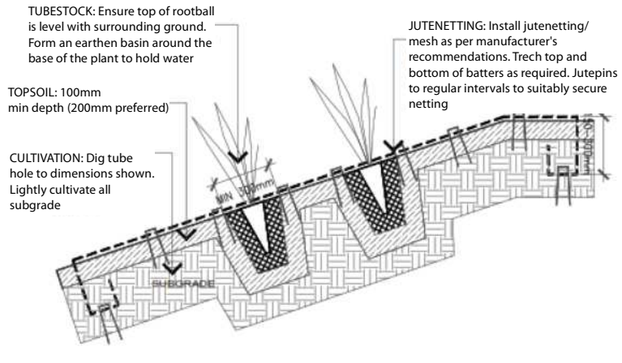
Typical planting details as below for standard medium mulch installation and jutenetting. Refer to manufacturer's recommendations for detailed jute netting installation including pinning, etc.

Plantings along drainage channels and adjacent waterbodies to generally comply with the Categories of Channel Vegetation figure below.

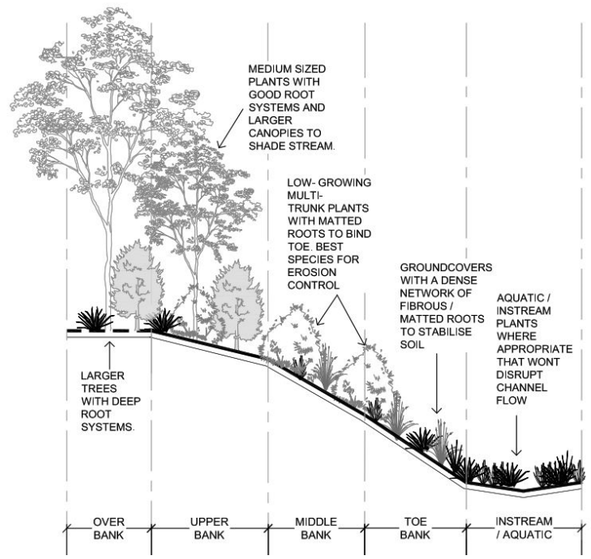
Each individual planting location should be spot cultivated to at least 2 times the depth and twice the width of the plant stock size. Refer detail for more specifications:



Where evidence of plant damage is occuring, tree guards grow tubes to be installed as required.

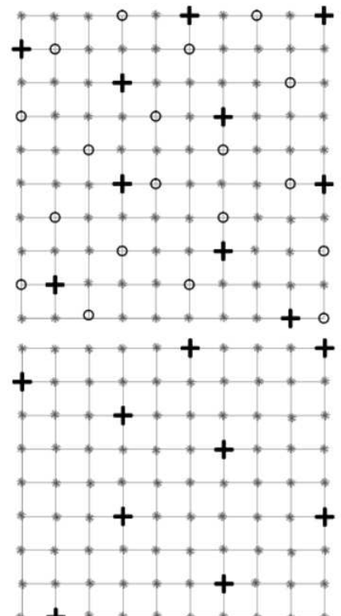


Jute netting mesh to be installed as per manufacturer's recommendations. Indicative detail shown only.



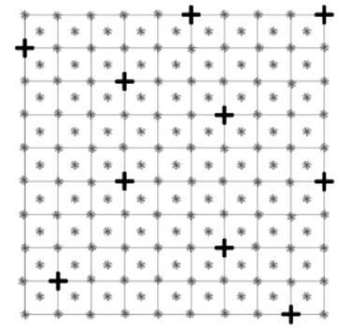
Categories of channel vegetation adapted from the Brisbane City Council Natural Channel Design Guidelines.

Revegetation planting locations shall be generally set out in accordance with a typical random grid pattern as shown below. Various typical densities shown. Refer to plant schedule for species and planting densities.

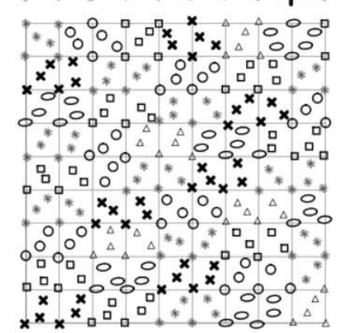


Typical 3 Tiered Revegetation Grid

Typical 2 Tiered Revegetation Grid



Typical 2 Tiered (Dense Groundcovers) Revegetation Grid



Typical Stormwater/ Biobasin Revegetation Grid

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REFERENCES:
South East Queensland Ecological Restoration Framework (2012)

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PROJECT:
38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 3/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF:
Rehabilitation Plan Notes

DATE:	10/11/2020	CHECKED:	JB/NC
CLIENT REF:	8868	DRAWN:	MC
DRAWING No.:	8868 E 12 CRP D		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - PLANTING SPECIES SCHEDULE

ANY CHANGES TO SPECIES AND RELATIVE QUANTITIES TO BE APPROVED BY COUNCIL AND ENVIRONMENTAL COORDINATOR PRIOR TO INSTALLATION

MANAGEMENT ZONE 1 – DRAINAGE FEATURE (FABRICATION)
TOTAL APPROXIMATE AREA = 2,310m² (Overall minimum density approximately 4 plants per 1 m²)

Notes:

1) Planting in zone to comprise groundcovers consistent with RE 12.3.5 / RE12.3.6 species that are adapted to higher levels of freshwater inundation.
2) Distribute plants in groups on site in random arrangement – to be confirmed with super intendant on site
3) All species of local provenance (recorded within 10km of site) from RE 12.3.6 technical description
4) Species to be planted according to tolerance of site conditions. Unsuitable or unavailable species to be substituted with others from schedule
5) Species quantities may be adapted by rehabilitation supervisor according to site conditions
6) Salt-tolerant species may be required at lowest elevations draining into Mangrove wetland. Substitute with saltwater tolerant groundcovers from Management Zone 6 of the Mangrove Rehabilitation Plan as required.

SCIENTIFIC NAME	COMMON NAME	PLANT FORM	POT SIZE	PLANTING DENSITY	QUANTITY REQUIRED
TREES				**4 PER 1 m²**	
Lomandra hystrix	Creek Matrush	Sedge-like	Tube	-	2,772 or 40%
Carex spp.	Tall Sedge	Grass	Tube	-	1,386 or 15%
Juncus usitatus	Common Rush	Rush	Tube	-	1,386 or 15%
Cyperus spp.	-	Sedge	Tube	-	370 or 4%
Dianella brevipedunculata / D. caerulea / D. longifolia	Lily	Sedge-like	Tube	-	370 or 4%
Fimbristylis spp.	Common Fringerush	Sedge	Tube	-	370 or 4%
Gahnia sieberiana	Red-fruit Saw-sedge	Sedge-like	Tube	-	370 or 4%
Lepidosperma laterale	Variable Sword Sedge	Sedge	Tube	-	370 or 4%
Scleria sp.	Nut Rush	Sedge	Tube	-	370 or 4%
Themeda triandra	Kangaroo Grass	Grass	Tube	-	370 or 6%
				TOTAL	**9,240**

^ = Only plant at locations experiencing waterlogging / frequent inundation

MANAGEMENT ZONE 2 & MANAGEMENT ZONE 3 – ADJACENT STORAGE LAGOON AND MANGROVE WETLAND & RE 12.3.5 / 12.3.6 BATTERS (RECONSTRUCTION)
TOTAL APPROXIMATE AREA = 20,250 m² (16,510 m² ADJACENT STORAGE LAGOON AND MANGROVE WETLAND & 3,740 m² BATTERS)
Overall minimum density approximately 2 plants per 1 m²)

Notes:

1) This zone comprises all Storage Lagoon areas and batters that may be subjected to periodic inundation i.e batters adjacent storage lagoon =<3m ASL.
2) All additional earthworks areas occurring within mapped RE 12.3.5/12.3.6 to be planted out in accordance with this zone.
2) Setback trees 3 metres minimum from all property boundaries, sewer and service alignments
3) Distribute plants in groups on site in random arrangement - to be confirmed with super intendant on site
4) All species of local provenance (recorded within 10km of site) from RE 12.3.5/12.3.6 technical description
5) Species to be planted according to tolerance of site conditions / level of anticipated inundation i.e Field inlet is RL 1.1m ASL therefore plant species to be adapted to regular inundation in this area while areas below weir level of 2.45m ASL to be adapted to periodic inundation.
6) Unsuitable or unavailable species to be substituted with others from schedule at discretion of rehabilitation supervisor
7) Species quantities may be adapted by rehabilitation supervisor according to site conditions
8) Extent of zone is subject to change following further investigation into anticipated waste water levels at full operation of WWTP. Advise planting salt-tolerant species from RE12.1.1 – *Casuarina glauca* forest amidst other plants at low elevations adjacent to Mangrove wetland as contingency for increased levels of salt-water inundation (above expected 1.7m ASL). Substitute with saltwater tolerant groundcovers from Management Zone 6 of the Mangrove Rehabilitation Plan as required.

SCIENTIFIC NAME	COMMON NAME	PLANT FORM	POT SIZE	PLANTING DENSITY	QUANTITY REQUIRED
TREES				**1 PER 10 m²**	
Eucalyptus tereticornis (D)	Forest Red Gum	T1	Tube	-	405 or 20%
Corymbia intermedia	Pink Bloodwood	T1	Tube	-	61 or 3%
Eucalyptus microcorys	Tallowwood	T1	Tube	-	61 or 3%
Elaeocarpus obovatus	Hard Quandong	T1	Tube	-	61 or 3%
Melaleuca quinquenervia (D)	Broad-leaved Paperbark	T2	Tube	-	405 or 20%
Lophostemon suaveolens (D)	Swamp Box	T2	Tube	-	405 or 20%
Glochidion ferdinandi &	Cheese Tree	T2	Tube	-	61 or 3%
Acacia melanoxylon	Black Wattle	T2	Tube	-	61 or 3%
Jagera pseudorhus	Foam Bark	T2	Tube	-	61 or 3%
Lophostemon confertus	Brush Box	T2	Tube	-	61 or 3%
Allocasuarina littoralis	Black She-oak	T2	Tube	-	61 or 3%
Acacia melanoxylon	Black Wattle	T2	Tube	-	61 or 3%
Melaleuca salicina	Willow Bottlebrush	T2	Tube	-	61 or 3%
Polyscias elegans	Celery Wood	T2	Tube	-	61 or 3%
Casuarina glauca &	Swamp She Oak	T2	Tube	-	100 or 5%
Cryptocarya triplinervis &		T2	Tube	-	41 or 2%
				SUBTOTAL	**2,025**
SHRUBS				**1 PER 5 m²**	
Alphitonia excelsa	Soap Tree	Sml tree / shrub	Tube	-	193 or 4.76%
Acacia leiocalyx / A. concurrens	Early Black Wattle	Sml tree / shrub	Tube	-	193 or 4.76%
Acacia disparrima &	Hickory Wattle	Sml tree / shrub	Tube	-	193 or 4.76%
Cupaniopsis anacardioides &	Tuckeroo	Sml tree / shrub	Tube	-	193 or 4.76%
Commersonia bartramii	Brown Kurrajong	Sml tree / shrub	Tube	-	193 or 4.76%
Melaleuca linariifolia / M. nodosa / M. sieberi	Paperbark	Sml tree / shrub	Tube	-	193 or 4.76%
Leptospermum polygalifolium / L juniperinum	Tea Tree	Sml tree / shrub	Tube	-	193 or 4.76%
Banksia oblongifolia	Dwarf Banksia	Shrub	Tube	-	193 or 4.76%
Melaleuca pachyphylla	Wallum Bottlebrush	Shrub	Tube	-	193 or 4.76%
Pittosporum revolutum &	Yellow Pittosporum	Shrub	Tube	-	193 or 4.76%
Banksia robur	Swamp Banksia	Shrub	Tube	-	193 or 4.76%
Myoporum acuminatum	Coastal Boobialla	Shrub	Tube	-	193 or 4.76%
Billardiera scanden	Apply Berry	Shrub	Tube	-	193 or 4.76%
Breynia oblongifolia	Coffee Bush	Shrub	Tube	-	193 or 4.76%
Hibbertia vestita	Hairy Guinea Flower	Shrub	Tube	-	193 or 4.76%
Hibiscus diversifolius	Swamp Hibiscus	Shrub	Tube	-	193 or 4.76%
Melastoma malabathricum	Blue Tongue	Shrub	Tube	-	193 or 4.76%
Glochidion sumatranum	Button Cheese	Shrub	Tube	-	193 or 4.76%
Hakea Actites	Wallum Hakea	Shrub	Tube	-	193 or 4.76%
Pultenaea retusa	Bush Pea	Shrub	Tube	-	193 or 4.76%
Trema tomentosa	Poison Peach	Shrub	Tube	-	193 or 4.76%
				SUBTOTAL	**4,050**
GROUND COVERS				**2 PER 1m²**	
Alloteropsis semialata	Cockatoo Grass	Grass	Tube	-	1,215 or 3%
Arundinella nepalensis	River Grass	Grass	Tube	-	1,215 or 3%
Baloskion pallens	Didgery Sticks	Rush	Tube	-	1,215 or 3%
Baumea articulata	Jointed Rush	Rush	Tube	-	1,215 or 3%
Capillipedium spicigerum &	Scented Top Grass	Grass	Tube	-	1,215 or 3%
Carex spp.	Tall Sedge	Grass	Tube	-	2,308 or 5.7%
Commelina diffusa	Native Commelina	Herb	Tube	-	1,215 or 3%
Cyperus spp.	-	Sedge	Tube	-	1,215 or 3%
Dianella brevipedunculata / D. caerulea / D. longifolia	Lily	Sedge-like	Tube		1,215 or 3%
Eleocharis spp.	-	Sedge	Tube	-	1,215 or 3%
Eremochloa bimaculata	Poverty Grass	Grass	Tube	-	1,215 or 3%
Eriachne pallescens	Wanderrie Grass	Grass	Tube	-	1,215 or 3%
Entolasia marginata / E. stricta &	Wiry Panic	Grass	Tube	-	1,215 or 3%
Eustrephus latifolius / Geitonoplesium cymosum	Wombat Berry / Scrambling Lily	Scrambler / vine	Tube	-	1,215 or 3%
Fimbristylis spp. &	Common Fringerush	Sedge	Tube	-	1,215 or 3%
Gahnia aspera	Rough Saw-sedge	Sedge	Tube	-	1,215 or 3%
Gahnia sieberiana	Red-fruit Saw-sedge	Sedge-like	Tube	-	1,215 or 3%
Juncus usitatus	Common Rush	Rush	Tube	-	2,308 or 5.7%
Leersia hexandra	Swamp Rice Grass	Grass	Tube	-	2,308 or 5.7%
Lepironia articulate	Grey Sedge	Sedge	Tube	-	2,308 or 5.7%
Lepidosperma laterale	Variable Sword Sedge	Sedge	Tube	-	1,215 or 3%
Lomandra hystrix	Creek Matrush	Sedge-like	Tube	-	2,308 or 5.7%
Ludwigia octovalvis	Willow Primrose	Herb	Tube	-	2,308 or 5.7%
Microlaena stipoides	Weeping Rice Grass	Grass	Tube	-	1,215 or 3%
Persicaria spp.	Knotweed / Smartweed	Macrophyte	Tube	-	1,215 or 3%
Philydrum lanuginosum	Woolly Frogmouth	Forb	Tube	-	1,215 or 3%
Scleria sp.	Nut Rush	Sedge	Tube	-	1,215 or 3%
Themeda triandra	Kangaroo Grass	Grass	Tube	-	2,308 or 5.7%
				SUBTOTAL	**40,500**
				TOTAL	**46,575**

D = Dominant species in stratum; & = Can by invasive. Plant in small quantities; & = Species is associated with RE 12.1.1 – Casuarina glauca woodland and will be suitable for planting as required at lower elevations adjacent to Mangrove Wetland that may experience infrequent saltwater inundation.

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REFERENCES:
Living with the Environment in the Pine Rivers Shire (Bowden 1999)
Ryan, T.S. (ed.) (2012) Technical Descriptions of Regional Ecosystems of Southeast Queensland, (Queensland Herbarium, Department of Science, Information Technology, Innovation and the Arts: Brisbane)
Bushfire Management Plan (LEC 2020)

AMENDMENTS:

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PROJECT:
38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 3/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF:
Rehabilitation Plan
Planting species schedule

DATE:	10/11/2020	CHECKED:	JB/NC
CLIENT REF:	8868	DRAWN:	MC
DRAWING No.:	8868 E 13 CRP D		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

CONCEPT REHABILITATION PLAN - PLANTING SPECIES SCHEDULE

ANY CHANGES TO SPECIES AND RELATIVE QUANTITIES TO BE APPROVED BY COUNCIL AND ENVIRONMENTAL COORDINATOR PRIOR TO INSTALLATION

MANAGEMENT ZONE 3 - RE 12.11.27 / 12.11.23 / 12.11.26 (60/30/10) EARTHWORKS AREAS FOR RECONSTRUCTION
RECOMMENDED SPECIES LIST TOTAL APPROXIMATE AREA = 15,115 (Overall minimum density approximately 2 plants per 1 m²)

Notes:
1) Planting of Land Zone 11 species will occur at upper elevations batters, and may also occur in additional earthworks areas and as infill planting in the Bushfire Protection Zone.
2) Setback trees 3 metres minimum from all property boundaries, sewer and service alignment
3) All species of local provenance (recorded within 10km of site) from RE 12.11.27 / 12.11.23 / 12.11.26 technical descriptions
4) Species to be planted according to tolerance of site conditions. Unsuitable or unavailable species to be substituted with others from schedule
5) Species quantities may be adapted by rehabilitation supervisor according to site condition / nursery availability
6) Extent of zone is subject to change following further investigation into anticipated waste water levels at full operation of WWTP

SCIENTIFIC NAME	COMMON NAME	PLANT FORM	POT SIZE	PLANTING DENSITY	QUANTITY REQUIRED
TREES				**1 PER 10 m²**	
Eucalyptus racemosa	Scribbly Gum	T1	Tube	-	79 or 5.26%
Eucalyptus pilularis	Blackbutt	T1	Tube	-	79 or 5.26%
Corymbia intermedia	Pink Bloodwood	T1	Tube	-	79 or 5.26%
Eucalyptus tindaliae	Tindale's Stringybark	T1	Tube	-	79 or 5.26%
Angophora woodsiana	Smudgee	T1	Tube	-	79 or 5.26%
Eucalyptus seeana	Narrow-leaved Red Gum	T1	Tube	-	79 or 5.26%
Eucalyptus microcorys	Tallowwood	T1	Tube	-	79 or 5.26%
Corymbia gummifera	Red Bloodwood	T1	Tube	-	79 or 5.26%
Euycalyptus resinifera	Red Mahogany	T1	Tube	-	79 or 5.26%
Eucalyptus propinqua	Small-fruited Grey Gum	T1	Tube	-	79 or 5.26%
Eucalyptus siderophloia	Grey Ironbark	T1	Tube	-	79 or 5.26%
Eucalyptus carnea	Broad-leaved White Mahogany	T1	Tube	-	79 or 5.26%
Eucalyptus tereticornis	Forest Red Gum	T1	Tube	-	79 or 5.26%
Ficus spp. (LF)	Fig	T1	Tube	-	79 or 5.26%
*Lophostemon suaveolens**	Swamp Box	T2	Tube	-	79 or 5.26%
Lophostemon confertus (LF)	Brush Box	T2	Tube	-	79 or 5.26%
*Glochidion ferdinandi (LF *)*	Cheese Tree	T2	Tube	-	79 or 5.26%
Allocasuarina littoralis	Black She-oak	T2	Tube	-	79 or 5.26%
*Melaleuca salicina**	Willow Bottlebrush	T2	Tube	-	79 or 5.26%
				SUBTOTAL	**1,510**
SHRUBS				**1 PER 5 m²**	
*Alphitonia excelsa **	Soap Tree	Sml tree / shrub	Tube	-	111 or 3.7%
A. concurrens	Early Black Wattle	Sml tree / shrub	Tube	-	111 or 3.7%
Acacia disparrima	Hickory Wattle	Sml tree / shrub	Tube	-	111 or 3.7%
Acacia falcata	Sickle Wattle	Sml tree / shrub	Tube	-	111 or 3.7%
*Cupaniopsis anacardioides (LF) **	Tuckeroo	Sml tree / shrub	Tube	-	111 or 3.7%
Pittosporum revolutum (LF)	Yellow Pittosporum	Sml tree / shrub	Tube	-	111 or 3.7%
Notelaea ovata / N. longifolia (LF)	Native Olive	Sml tree / shrub	Tube	-	111 or 3.7%
Eupomatia laurina (LF)	Bolwarra	Sml tree / shrub	Tube	-	111 or 3.7%
*Leptospermum polygalifolium **	Wild May	Shrub	Tube	-	111 or 3.7%
Elaeocarpus reticulatus (LF)	Ash Quandong	Shrub	Tube	-	111 or 3.7%
Banksia spinulosa (LF)	Hairpin Banksia	Shrub	Tube	-	111 or 3.7%
Dodonaea triquetra (LF)	Hop Bush	Shrub	Tube	-	111 or 3.7%
*Glochidion sumatranum (LF) **	Button Cheese	Shrub	Tube	-	111 or 3.7%
Hakea florulenta (LF)	3-nerved Willow Hakea	Shrub	Tube	-	111 or 3.7%
Hovea acutifolia (LF)	Purple Pea Bush	Shrub	Tube	-	111 or 3.7%
Jacksonia scoparia (LF)	Dogwood	Shrub	Tube	-	111 or 3.7%
Trema tomentosa	Poison Peach	Shrub	Tube	-	111 or 3.7%
Pultenaea villosa (LF)	Hairy Bush Pea	Shrub	Tube	-	111 or 3.7%
Billardiera scanden	Apple Berry	Shrub	Tube	-	111 or 3.7%
*Breynia oblongifolia (LF) **	Coffee Bush	Shrub	Tube	-	111 or 3.7%
Leucopogon juniperinus	Prickly Beard Heath	Shrub	Tube	-	111 or 3.7%
Psychotria loniceroides (LF)	Hairy Psychotria	Shrub	Tube	-	111 or 3.7%
Lomatia silaifolia (LF)	-	Shrub	Tube	-	111 or 3.7%
Hibbertia sp. (LF)	-	Shrub	Tube	-	111 or 3.7%
Hardenbergia violacea (LF)	Native Sarsparilla	Shrub	Tube	-	111 or 3.7%
Daviesia ulicifolia	Gorse Bitter Pea	Shrub	Tube	-	111 or 3.7%
Phyllanthus gunnii	Scrubby Spurge	Shrub	Tube	-	111 or 3.7%
				SUBTOTAL	**3,023**
GROUND COVERS				**1 PER 1.5 m²**	
Themeda triandra (LF)	Kangaroo Grass	Grass	Tube	-	1995 or 6.6%
Cymbopogon refractus	Barbed Wire Grass	Grass	Tube	-	1995 or 6.6%
Alloteropsis semialata	Cockatoo Grass	Grass	Tube	-	1995 or 6.6%
Aristida calycina	Dark Wiregrass	Grass	Tube	-	1995 or 6.6%
*Dianella caerulea / D. longifolia (LF) **	Lily	Sedge-like	Tube	-	1995 or 6.6%
Eragrostis Brownii	Brown's Lovegrass	Grass	Tube	-	1995 or 6.6%
Gahnia aspera	Rough Saw Sedge	Sedge	Tube	-	1995 or 6.6%
Entolasia stricta	Wiry Panic	Grass	Tube	-	1995 or 6.6%
Eremochloa bimaculata	Poverty Grass	Grass	Tube	-	1995 or 6.6%
Lepidosperma laterale	Variable Sword Sedge	Sedge	Tube	-	1995 or 6.6%
*Lomandra longifolia (LF) **	Matrush	Sedge-like	Tube	-	1995 or 6.6%
Lomandra multiflora (LF)	Many-flowered Matrush	Sedge-like	Tube	-	1995 or 6.6%
Lomandra confertifolia / L. laxa (LF)	Matrush	Sedge-like	Tube	-	1995 or 6.6%
Microlaena stipoides	Weeping Rice Grass	Grass	Tube	-	1995 or 6.6%
Eustrephus latifolius / Geitonoplesium cymosum (LF)	Wombat Berry / Scrambling Lily	Scrambler / vine	Tube	-	1995 or 6.6%
Imperata cylindrica	Blady Grass	Grass	Tube	-	302 or 1%
				SUBTOTAL	**30,230**
				TOTAL	**34,763**

D = Dominant species in stratum; & = Can by invasive. Plant in small quantities; LF = Less flammable species; * = adapted to moist conditions

MANAGEMENT ZONE 4 – LANDSCAPE TURF BUFFER / SERVICE EASEMENT (FABRICATION)
RECOMMENDED SPECIES LIST TOTAL APPROXIMATE AREA = 9,700

Notes:
1) Turf / hydro seed mix to be approved by Council and Environmental Coordinator prior to installation.
2) Green Couch may be substituted with an alternative, low-maintenance, native grass where appropriate

SCIENTIFIC NAME	COMMON NAME	PLANT FORM	POT SIZE	PLANTING DENSITY	QUANTITY REQUIRED
TURF					
Cynodon dactylon	Green Couch	Grass	Turf	m²	3,790
				SUBTOTAL	**3,790**
HYDROSEED					
		Grass	Hydroseed	m²	5,910
				SUBTOTAL	**5,910**
				TOTAL	**9,700**

MANAGEMENT ZONE 5 – SCATTERED NJKHT (FABRICATION)
RECOMMENDED SPECIES LIST TOTAL APPROXIMATE AREA = 2,225

Notes:
1) Setback trees 3 metres minimum from all property boundaries, sewer and service alignment and as far away from existing powerlines as possible
2) Distribute plants at 10m centres along either side of services / powerline easement—which is approximately 500m in length)
3) All species in schedule are being removed along easement to facilitate installation of trunk services (refer to approved VCFMP)
4) Hydro seed mix to be approved by Council and Environmental Coordinator prior to installation.

SCIENTIFIC NAME	COMMON NAME	PLANT FORM	POT SIZE	PLANTING DENSITY	QUANTITY REQUIRED
TREE				**1 per 10m centres**	
Eucalyptus tereticornis	Forest Red Gum	T1 Tree			13
Eucalyptus siderophloia	Grey Ironbark	T1 Tree			13
Corymbia intermedia	Pink Bloodwood	T1 Tree			13
Eucalyptus racemosa	Scribbly Gum	T1 Tree			12
Eucalyptus acmenoides	White Mahogany	T1 Tree			12
Eucalyptus microcorys	Tallowwood	T1 Tree			12
Eucalyptus resinifera	Red Mahogany	T1 Tree			12
Lophostemon confertus	Brush Box	T2 Tree			13
				SUBTOTAL	**100**
HYDROSEED					
		Grass	Hydroseed	m²	2,225
				SUBTOTAL	2,225

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CLIENT: lendlease

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PRIOR TO ANY DEMOLITION, EXCAVATION OR CONSTRUCTION ON SITE, THE RELEVANT AUTHORITY SHOULD BE CONTACTED FOR FURTHER UNDER-GROUND SERVICES AND DETAILED LOCATIONS OF ALL SERVICES.

REFERENCES:
Living with the Environment in the Pine Rivers Shire (Bowden 1999)
Ryan, T.S. (ed.) (2012) Technical Descriptions of Regional Ecosystems of Southeast Queensland, (Queensland Herbarium, Department of Science, Information Technology, Innovation and the Arts: Brisbane)
Bushfire Management Plan (LEC 2020)

AMENDMENTS:

Issue	Date	Description	Checked
A	23/07/2020	Preliminary	TL/KG/NC
B	19/08/2020	DAF updates	TL/KG/NC
C	29/09/2020	DAF updates	TL/KG/NC
D	10/11/2020	STP updates	JB/NC

PROJECT:
38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 3/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF:
Rehabilitation Plan
Planting species schedule

DATE:	10/11/2020	CHECKED:	JB/NC
CLIENT REF:	8868	DRAWN:	MC
DRAWING No.:	8868 E 14 CRP D		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT
CONCEPT REHABILITATION PLAN - MAINTENANCE & MONITORING

METHODOLOGY – FAUNA NOTES

Consideration for fauna habitat and values should be given during rehabilitation site works and should seek to enhance and restore the existing native vegetation areas and promote safe fauna movement throughout the site and into the larger greenspace corridors where possible. It is assumed properties adjacent to the rehabilitation scope of works will undertake individual site analysis, fauna investigations, and implement future measures as required.

As part of these rehabilitation works, basic fauna works will be undertaken. These treatments will primarily involve:

- Fauna Habitat Value and Protection
- Increased fauna habitat value within the rehabilitation areas.

Fauna habitat value and protection

Rehabilitation Areas to include reuse of site fallen hollow logs and site rock to create fauna safe havens and cover from predators for small fauna. This approach coupled with additional revegetation works allows greater fauna security and movement within the rehabilitation areas. Consideration for bushfire requirements should be reviewed to confirm no conflict in both the fauna and rehabilitation approaches.

METHODOLOGY – MAINTENANCE & MONITORING

Maintenance, as with all ecological restoration work, is fundamental in ensuring project success. Maintenance is required following installation of the plants, and will be the responsibility of Lendlease for the duration of the five (5) year establishment period. Responsibility for maintenance will then be given to Redland Water and Redland City Council (Parks), who will maintain the site in perpetuity. On-going maintenance at the site will ensure that the desired end-product—a fully-functioning system that can support itself in perpetuity, with minimal maintenance and input required—is achieved.

Maintenance of the planting includes tasks such as:

- Herbicide spraying to control competing weeds.
- Watering while plants are establishing. This is often highly variable and depends on the suite of species planted, weather conditions and time of year when planted. A watering schedule may consist of watering every day for week 1, twice per week for weeks 2-6 and then weekly from weeks 6-12.
- Repair of tree guards if they become damaged.
- Replenishment of mulch.
- Maintaining exclusion fencing; and
- Additional planting if required.

Additional planting may be required to replace plants that do not survive (e.g.to meet survival rate requirements, or to fill gaps), but it may also be necessary to introduce new species at different stages of vegetation succession. An adaptive management approach should be utilised, if one plant species consistently dies on a site, consider using in its place a species that is performing well.

A typical two (2) year maintenance schedule is provided below. If maintenance is regular and thorough during the first two (2) years, maintenance requirements are likely to taper off significantly in the following years.

Benchmark criteria / performance indicators

The utilisation of benchmark criteria helps to determine rehabilitation success during the maintenance period and assists in prompting when additional maintenance activities are required. Typically accepted benchmarks or performance indicators for dedicated or open space rehabilitation works include:

- Compliance 'On Maintenance' requirements:
  - All required planting completed.
  - 98% plant survival.
  - 100% kill rate of declared environmental weeds.
  - 98% kill rate of other weeds
- Ongoing 'Off Maintenance' requirements:
  - 95% plant survival.
  - Tree guards, stakes and general rubbish removed.
  - No remaining eroded or degraded areas.
  - 100% kill rate of declared environmental weeds.
  - 98% kill rate of other weeds

Monitoring

Informal monitoring of rehabilitation works is another method of determining ecological restoration success in conjunction with the adjacent benchmarks. Informal monitoring may occur through ongoing site inspections, completion of record sheets and note taking. Notes to be distributed to the rehabilitation team and rectification works completed against notes.

Photo point monitoring is an effective form of informal monitoring that may be used to support note taking, and may be requested during the approval process by the assessment manager. A permanent or semi-permanent photo point can be set up using a star picket marked with fluorescent yellow safety cap or painted timber stakes, so that a photograph may be taken of the site at regular (quarterly) intervals as it is being restored. A time series of photographs from a degraded state prior to the commencement of restoration, through the transition stages and into the maintenance stage will assist in assessing the success of the ecological restoration process. Collected site data and photos should be compiled in a 'master' monitoring report for proper record keeping.

Monitoring of the weed management and revegetation works allows practitioners to:

- Monitor the rate of assisted regeneration and revegetation of desirable native species promoted in areas where weeds have been removed i.e. number and species of native seedlings established that were not planted on site
- Ensure level of protection for existing identified native vegetation inclusive of that which has naturally regenerated.
- Review the rate of spread or contraction of weed infestation within the weed removal and control program i.e. has weed growth been inhibited by current control program or has it spread to newly disturbed areas?
- Identification of new weed threats or other factors that may be affecting areas designated for rehabilitation i.e. have additional scour locations been identified?
- Review of the benchmark criteria / pre-established performance indicators for measuring the success of the weed removal and control program i.e. has the rate of weed removal on ground reached the benchmark criteria for On or Off Maintenance?

Monitoring timeframes may involve a series of key milestones:

- Prestart Inspection - On site meeting prior to the initial commencement of work. Typically involves Consultant, Contractor and Assessment Manager to work through rehabilitation areas and clarify any adjustments to scope against approved works.
- Compliance Inspections - At the completion of the Primary Site Works, a compliance inspection meeting will be held with the Consultant, Contractor and Assessment Manager to inspect the works on-site in relation to the approved plans and previously agreed benchmarks performance indicators. Should the rehabilitation be a dedicated asset (open space) to the assessment manager, this inspection is commonly referred to as 'on maintenance'. For dedicated assets, a secondary compliance inspection will be required (off maintenance).
- Ongoing Monitoring Inspections- Informal monitoring to occur on a regular basis as highlighted above. These inspections will generally occur throughout the process, specifically before, during and after relevant compliance inspections.

Monitoring during the five (5) year establishment period will be the responsibility of Lendlease, and will require quarterly monitoring in the first year while rapid changes are occurring followed by bi-monthly reporting. Monitoring responsibilities will then be handed over to Redland Water and Redland City Council (Parks). The monitoring program can be reviewed at this time, and a longer-term, less intensive program proposed where required.

Adaptive management

Adaptive management is an on-going, systematic approach for improving rehabilitation outcomes by learning from existing management techniques. It is a cyclic process involving:

1. identification of unsuccessful treatments and new threats during monitoring events
2. investigation of new and alternative treatments
3. implementation of new / alternative management strategies based on best available knowledge
4. review of new / alternative management strategies during monitoring

Adopting an adaptive approach to rehabilitation works is recommended to achieve benchmark criteria and maximise environmental outcomes for the site.

Progress Reporting

Following implementation of this plan, it is important that the techniques/methods and outcomes from maintenance and monitoring visits are documented. This should be undertaken, even when projects are not successful, to assist with potential information gathering for future projects, particularly if problems can be documented.

Responsibilities

It is also critical for all parties to understand their responsibilities as part of the overall rehabilitation 'team'.

REHABILITATION TEAM RESPONSIBILITIES	
PARTY	**DESCRIPTION**
Proponent	Ensure all consultants, contractors, sub contractors or others utilizing the area are aware of the Rehabilitation Plan. Appoint appropriate consultants and contractors to undertake works as prescribed on the drawings and conditioned by the Assessment Manager. Provide security via an uncompleted works bond and maintenance bond for the cost of works if required. Cover the costs of all necessary resources to ensure works are completed as per the approved documents.
Consultants	Brief proponent on their requirements in implementing and maintaining works as per the Rehabilitation Plan. Attend pre-start and compliance (on and off maintenance) inspections. Undertake monitoring and reporting to the Assessment Manager as set up by this document. Be available to respond to technical queries to the approved documentation when on-site conditions require changes. Liaise with the Assessment Manager throughout all stages of approval, initial works and maintenance of works.
Assessment Manager	Provide technical expertise via commentary on the approval of documentation. Reduce and release securities held against works at the completion of successful milestone inspections. Be available to respond to technical queries to the approved documentation when on-site conditions require changes. Accept and review maintenance reports as dictated (if required) in this document.
Contractor	Complete works in strict accordance with the documentation. Attend pre-start and compliance (on and off maintenance) inspections. Hold relevant licenses in applicable weed management/ revegetation/ fauna management Hold relevant licenses in applicable weed management/ revegetation/ fauna management i.e. minimum Certificate III in Conservation and Land Management, Certificate III in Horticulture, or Certificate III in Rehabilitation Construction, or equivalent experience in rehabilitation. Expertise in wetland rehabilitation is highly recommended. Any required insurances for scope of works and an understanding of required Laws, Act, Policies and Guidelines. Recommend changes to the documentation when specific experience or on-site conditions require so.

COLOUR KEY TO WORK ITEMS
Weed Management
Soil Preparation and Mulching
Planting Works
Watering, Monitoring and Reporting

REHABILITATION WORKS - INDICATIVE SCHEDULE OF WORK ITEMS AND MAINTENANCE SEQUENCING (NOTE MAINTENANCE PERIOD TO BE CONFIRMED BY ASSESSMENT MANAGER)

TIMING	SPRING				SUMMER			AUTUMN			WINTER			SPRING			SUMMER			AUTUMN			WINTER			SPRING			
	PRIMARY WORKS				FOLLOW-UP WORKS			FOLLOW-UP / MAINTENANCE WORKS			MAINTENANCE WORKS			MAINTENANCE WORKS			MAINTENANCE WORKS			MAINTENANCE WORKS			MAINTENANCE WORKS			MAINTENANCE WORKS			
	Month 1	Month 2	Month 3		Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	
WEEK 1	Pre-start meeting Council, Contractor and Superintendent	Establish photo points if required. Weed management - "knockdown spray"	Mulch spreading and Jute-mat installation	MILESTONE: COMPLIANCE / "ON MAINTENANCE"	Watering and Monitoring and reporting (throughout establishment). Photo monitoring as required	Watering and Monitoring and reporting (throughout establishment). Photo monitoring as required	Watering and Monitoring and reporting (throughout establishment). Photo monitoring as required	Watering to replacement plants only.	Watering to replacement plants only.	Monitoring and reporting. Photo monitoring as required	watering to replacement plants only.		Monitoring and reporting. Photo monitoring as required.	Watering to replacement plants only		Monitoring and reporting. Photo monitoring as required.	Watering to replacement plants only		Monitoring and reporting. Photo monitoring as required.	Watering to replacement plants only		Monitoring and reporting. Photo monitoring as required.	Watering to replacement plants only		Monitoring and reporting. Photo monitoring as required.	Mulch - top up depths to 100mm and replace / repair Jutematting as required	Watering to replacement plants only	Monitoring and reporting. Photo monitoring as required.	MILESTONE: COMPLIANCE / "OFF MAINTENANCE"
WEEK 2	Initial weed management works - wood weed removal /"knockdown" spray	Soil Preparation and cultivation	Natural regeneration plants staking for identification		Weed management - "knockdown spray" in mulched areas	Weed management - "knockdown spray" re-apply woody weeds	Weed management - "knockdown spray" in mulched areas	Weed management - rotation "knockdown spray" in mulched areas	Weed management - rotation "knockdown spray" in mulched areas	Weed management - rotation "knockdown spray" in mulched areas	Weed management - rotation "knockdown spray" in mulched areas		Weed management - rotation "knockdown spray" in mulched areas	Weed management - rotation "knockdown spray" in mulched areas		Weed management - rotation "knockdown spray" in mulched areas	Weed management - rotation "knockdown spray" in mulched areas		Weed management - rotation "knockdown spray" in mulched areas	Weed management - rotation "knockdown spray" in mulched areas		Weed management - rotation "knockdown spray" in mulched areas	Weed management - rotation "knockdown spray" in mulched areas		Weed management - rotation "knockdown spray" in mulched areas	Natural regeneration plants - weed management	Weed management - "knockdown spray" re-apply woody weeds	Weed management - "knockdown spray" in mulched areas	
WEEK 3	Weed management works - removal by hand	Soil Preparation and modification	Planting and Watering		Natural regeneration plants - weed management	Replacement of Failed Plants	Replacement of Failed Plants	Natural regeneration plants - weed management	Natural regeneration plants - weed management	Replacement of Failed Plants	Natural regeneration plants - weed management		Trees formative pruning			Replacement of Failed Plants						Natural regeneration plants - weed management		Trees formative pruning				Trees formative pruning	Replacement of Failed Plants	Natural regeneration plants - weed management	
WEEK 4	Weed Management - slashing of maintenance access paths	Mulch - stockpiled on site	Planting and Watering		Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths		Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths		Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths		Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths		Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths		Weed Management - slashing of maintenance access paths	Replacement of Failed Plants	Weed Management - slashing of maintenance access paths	Weed Management - slashing of maintenance access paths	

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REFERENCES:
South East Queensland Ecological Restoration Framework (2012)

AMENDMENTS:

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A	23/07/2020	Preliminary	TL/KG/NC
B	19/08/2020	DAF updates	TL/KG/NC
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PROJECT:
38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 3/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF:
Rehabilitation Plan
Notes

DATE:	10/11/2020	CHECKED:	JB/NC
CLIENT REF.:	8868	DRAWN:	MC
DRAWING No.:	8868 E 15 CRP D		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

APPENDIX A - WEED SCHEDULE

CHEMICAL CONTROL METHODS NOT TO BE USED IN OR NEAR WATERWAYS; IN LEAD UP TO PREDICTED RAINFALL OR BETWEEN PERIOD OF EGG-LAYING TO DISPERSAL OF JUVENILE FROGS OF LOCAL PROVENANCE.

Eleven (11) restricted invasive plant (Class 3) species under the *Biosecurity Act 2014* were identified on site. Four (4) of these species are also classified as Weeds of National Significance (WoNS). These species are listed below with effective control and removal methods adapted from the Business Queensland website.

Scientific name	Common Name	Listing	Physical control	Mechanical	Chemical control methods	Other controls
Asparagus africanus	Climbing Asparagus	Restricted, WoNS	• Prevent birds from accessing berries. • Dig out roots and dispose of them at your local waste facility. • Remove entire crown and underground stem to prevent regrowth. This requires digging underneath the central growing point and lifting it out of the ground. Any regrowth that occurs can be kept under control by regular mowing or digging out.		• There are no herbicide products specifically registered for the control of asparagus ferns grass in Queensland. However, a permit held by the Department of Agriculture and Fisheries allows people generally to use some herbicide products to control asparagus ferns as an environmental weed in various situations. • Refer to Asparagus Fern Fact Sheet for herbicide control and application rates	• No known biological control agents.
Baccharis halimifolia	Groundsel	Restricted	• Hand-pull small plants. • Dig larger plants out or cut them off more than 10cm below ground level.	• As groundsel bush is a perennial woody plant with underground growing buds, slashing or burning will rarely kill plants and will generally result in regrowth. Control regrowth promptly.	• Herbicides are effective. • See the Groundsel bush fact sheet for herbicide control and application rates.	• More than 35 different insects have been tested since 1967, with 6 now permanently established: • Rust fungus Puccinia evadens from Florida was also released in 1998 and is now established. Infection requires a moisture film on leaf or stem surface. Dry spores are spread by wind. • Three agents Puccinia evadens, Hellinsia balanotes and Rhopalomyia californica are thought to contribute to control over most of weed's range.
Cardiospermum grandiflorum	Balloon Vine	Restricted	• Manually remove small infestations. • Hand-pull roots.	• Use a brush hook or similar to remove thicker growth from top of plant.	• Combine manual and herbicide control to prevent regrowth. • See the Balloon or heart seed vine fact sheet for herbicide control and application rates.	• No known biological control agents.
Cinnamomum camphora	Camphor Laurel	Restricted	• hand pull newly established or isolated seedlings • Fire (kills plant tops but produces regrowth from base	• Remove newly established or isolated seedlings by grubbing. • Bulldoze young trees that can be completely removed. Failure to remove roots or crowns of mature trees will result in regrowth.	Herbicide • depends on size and situation of target tree. • Treating standing tree may create serious hazard to human safety or other structures when tree falls. Removing bulk of tree before treating stump is preferred in such situations. Foliar spray for young trees up to 3m tall. Basal bark spray • Trees up to 6m tall with a basal stem diameter up to 30cm and no multi-stems can be treated using basal bark or cut-stump methods, although basal bark is preferred. • When using basal bark method, spray from ground level up to 30cm or higher than where multi-stems branch. Stem injection • For trees taller than 6m, stem injection using modified axe is most practical — leave no more than 2cm between cuts. • Axe cuts for stem injection of herbicides should be made at regular intervals all around stem (or stems). Care should be taken to ensure axe leaves 'pocket' in stem, into which herbicide is immediately injected. Cuts should penetrate sapwood (just under bark), but not hard central wood. Cuts made too shallow into bark or too deep into stem will result in regrowth. Drilling holes in stem before herbicide application is not recommended. • See the Camphor laurel fact sheet for herbicide control and application rates.	• No known biological control agents.
Lantana camara	Lantana	Restricted, WoNS	Fire • Burn regularly to reduce lantana's survival, but be aware that initial kill rates will vary. Effectiveness of burning will depend on the suitability of available fuel loads, fire intensity, temperature, relative humidity, soil moisture and season. • Then re-establish pasture to provide competition to inhibit lantana seed germination. • Fire is not recommended in areas such as rainforest and wooded or plantation areas, which are not fire-tolerant.	• Stick raking or ploughing can be effective in removing standing plants. However, regrowth from stumps and/or increased seedling germination in disturbed soil is common and the site will require follow-up treatment. • Grubbing of small infestations (for example, along fence lines) can be a useful and effective way to remove plants, but is time-consuming. • Repeated slashing can also reduce lantana's vigour, exhausting its stored resources and reducing its likelihood of re-shooting. • Some locations (for example, very steep inclines or gullies) are not suitable for mechanical control options because of the danger of overturning machinery and soil erosion.	• Variation in results can be a result of inconsistent application methods, mix rates or seasonal variation. Red-flowered and pink-edged red-flowered lantana are often considered the most difficult to control because their leaves are often smaller and tougher. However, herbicides can kill these varieties if you follow application procedures carefully. • For single-stemmed lantana, basal bark spraying and cut-stump methods also give good results at any time of year (but best when the plant is actively growing). On multi-stemmed varieties, obtain best results by carefully applying herbicide to each stem. • When treating actively growing plants less than 2m tall, spray foliage overall to the point of run-off. Splatter gun techniques are also effective and particularly useful in hard-to-access areas. This is best done in autumn, when sap-flows draw the poison down into the root stock, but before night temperatures get too cold. • Remove grazing animals from spray areas during and soon after treatment. Stress can cause increased sugar levels in the leaves of lantana plants, making them more palatable. • See the Lantana fact sheet for herbicide control and application rates.	Biosecurity Queensland research programs continue to investigate agents suitable for release in Australia.Biological control alone should not be relied on to manage lantana infestations. Consider other available control techniques. The 4 most important biological control agents are: • sap-sucking bug (Teleonemia scrupulosa) • leaf-mining beetle (Uroplata girardi) • leaf-mining beetle (Octotoma scabripennis) • seed-feeding fly (Ophiomyia lantanae).Other agents such as Aconophora compressa (a stem-sucking bug) and Leptobyrsa decora (a sap-sucking bug) have caused some damage in specific geographic areas.
Opuntia stricta	Common Pest Pear	Restricted, WoNS	• Fire is an effective control method for dense prickly pear infestations. Before burning, consult Biosecurity Queensland to see if this practice is suitable for your pasture and land management practices.	• Using machinery is unsatisfactory because prickly pear pads can easily re-establish.	• Herbicides • Basal bark spraying • Cut-stump method • See the Opuntioid cacti fact sheet (PDF, 12.4MB) for herbicide control and application rates.	• 8 insects and the mite remain established in Queensland. • These biological control agents continue to keep several prickly pears under control. Not all of them attack all prickly pears. • Most successful of these species were the Cactoblastis stem-boring moth and the four cochineal mealybugs. The other agents remain but not in sufficient numbers to provide control.

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REFERENCES:

Business Queensland Website (https://www.business.qld.gov.au/).

AMENDMENTS:

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A	23/07/2020	Preliminary	TL/KG/NC
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C	29/09/2020	DAF updates	TL/KG/NC
D	10/11/2020	STP updates	JB/NC

PROJECT:

38 LONGLAND ROAD
REDLAND BAY
(2/RP223470, 3/RP223470
1/SL3427, 254/S31102)

environmental management

PLAN OF:

Weed Schedule

DATE:	23/08/2019	CHECKED:	JB/NC
CLIENT REF.:	8868	DRAWN:	MC
DRAWING No.:	8868 E AA CRP D		

SOUTHERN REDLAND BAY WASTEWATER TREATMENT PLANT

APPENDIX A - WEED SCHEDULE

CHEMICAL CONTROL METHODS NOT TO BE USED IN OR NEAR WATERWAYS; IN LEAD UP TO PREDICTED RAINFALL OR BETWEEN PERIOD OF EGG-LAYING TO DISPERSAL OF JUVENILE FROGS OF LOCAL PROVENANCE.

Scientific name	Common Name	Listing	Physical control	Mechanical	Chemical control methods	Other controls
Lantana montevidensis	Creeping Lantana	Restricted	Pasture management • Monitor pasture condition and spell and re sow as required. • Conservative stocking rates combined with some form of pasture spelling and judicious use of fire is likely to be the most effective way to maintain the vigour and competitive ability of native pastures. Fire • Burn regularly to reduce lantana's survival, but be aware that initial kill rates will vary. Effectiveness of burning will depend on the suitability of available fuel loads, fire intensity, temperature, relative humidity, soil moisture and season.Then re-establish pasture to provide competition to inhibit lantana seed germination	• Stick raking, dozing or ploughing can b effective in removing plants. However, regrowth from stumps and/or increased seedling germination in disturbed soil is common and the site will require follow-up treatment • Grubbing of small infestations (for example, along fence lines) can be a useful and effective way to remove plants, but is time-consuming. • Repeated slashing can also reduce creeping lantana's vigour, exhausting its stored resources and reducing its likelihood of re-shooting.	• Variation in results can be a result of inconsistent application methods, mix rates or seasonal variation, follow up application is important. • Remove grazing animals from spray areas during and soon after treatment. Stress can cause increased sugar levels in the leaves of lantana plants, making them more palatable. • See the Lantana fact sheet for herbicide control and application rates, check on the label that it is recommended for Lantana montevidensis.	• No known biological control agents
Schinus terebinthifolius	Broadleaf Pepper Tree	Restricted	• Hand-pull or chip out young plants. • Remove trees in winter.	• Felled trees may regrow from suckers for up to 18 months. If chopping, mulch branches, especially if trees have seed. Alternatively, cut trees 5cm below soil, chip away bark and nail tin plate over stump.	• Herbicides are available using foliar application, basal bark and cut-stump methods. See the Broadleaved pepper tree fact sheet for herbicide control and application rates.	• No known biological control agents
Senecio madagascariensis	Fireweed	Restricted, WoNS	• Prevent establishment by ensuring dense cover of pasture in autumn and winter. • Remove small infestations immediately.	• Chip out, bag and burn isolated plants. Wear gloves when handling fireweed plants. • Slashing is usually not effective, as it increases poisoning risk to stock and only delays flowering and seeding. • Cultivation is not recommended. • Fireweed remains toxic after being cut and becomes more attractive to stock.	• Herbicides are most effective if sprayed before plants reach maturity. However, application during flowering will be effective if higher recommended rates of herbicide are applied. • Trials have shown herbicide application in the autumn period during April provides good control. Before undertaking such programs, landholders are advised to determine infestation levels. • Effective application method in an open pasture situation is a boom spray. Follow this up by spot spraying, or pulling and bagging any regrowth or missed plants. • Boom spraying is also suitable for follow-up treatments, as it allows destruction of immature plants, which may otherwise grow to re-seed the area before they can be noticed. • Bromoxynil is effective if used on seedlings, which usually appear in autumn and early winter but may appear later following rain. Twice as much bromoxynil is needed if it is applied to plants that are just beginning to flower. Bromoxynil is less effective on mature plants, as it is a contact herbicide only. Mature plants will only be killed off where the bromoxynil comes into contact with the plant, allowing recovery of the plant from lower, untouched portions. • Conduct follow-up inspections every 4 months after initial treatment. Re-treat as required. • Unfortunately, fireweed control is often not considered until the highly visible flowers appear and it is too late for effective control with herbicide. • See the Fireweed fact sheet for herbicide control and application rates.	• Organisms can be found attacking fireweed, but any effect they have is temporary and isolated. • Orange rust (Puccinia lagenophorae) is common and often affects fireweed, particularly in lower country. • Blue stem borer moth (Patagoniodes farinari) is also common, but larvae usually develop too slowly to have an impact. • Two moths imported from Madagascar have been host tested. In controlled tests they were found to feed on important non-target plants so no releases were made. • Other potential biological control agents have been identified, but rigorous testing is needed to ensure that they do not feed on closely related Australian native plants. Investigations in South Africa are presently being undertaken.
Sphagneticola trilobata	Singapore Daisy	Restricted	• Hand pulling - can be an effective control as it can minimize soil disturbance and can instantly remove the entire weed. • Dig up runners • Dispose of waste carefully, as smallest cutting can regrow.	• Mechanical control suits larger infestations, using power tools and machinery to reduce the bulk of the problem. • Mechanical control can include slashing, mowing, dozing, harvesting, and felling.	• Foliar Spray - Herbicide is diluted with water at a specific rate, and sprayed over the foliage to point of runoff. Most suited to shrubs, grasses and dense vines less than six metres tall. • Before using any herbicide always read the label carefully and ensure that the chemical is registered for use on the target weed. All herbicides must be applied strictly in accordance with the directions on the label. • See the Singapore daisy fact sheet for herbicide control and application rates.	• No known biological control agents
Tecoma stans	Yellow Bells	Restricted	• Hand-pull seedlings or using hand tools can be an effective control as it can minimize soil disturbance and can instantly remove the entire weed • Do not break taproot if removing by hand as regrowth is likely.	• Mechanical control suits larger infestations, using power tools and machinery to reduce the bulk of the problem. • Mechanical control can include slashing, mowing, dozing, harvesting, and felling.	• Herbicides can be effective • Herbicide is diluted with water at a specific rate, and sprayed over the foliage to point of runoff. • Most suited to shrubs, grasses and dense vines less than six metres tall.	• No known biological control agents

Other species recorded onsite that are not listed under the state or commonwealth are as follows:

Scientific name	Common Name	Scientific name	Common Name	Scientific name	Common Name	Scientific name	Common Name
Ageratina riparia	Mistflower	*Digitaria didactyla*	Queensland Couch	*Nephrolepis cordifolia*	Fishbone Fern	*Sida cordifolia*	Flannel Weed
Ageratum houstonianum	Blue Billygoat Weed	*Duranta erecta*	Duranta	*Nymphaea caerulea*	Blue Water Lilly	*Solanum mauritianum*	Wild Tobacco
Alternanthera denticulata	Lesser Joy Weed	*Gomphocarpus physocarpus*	Balloon Cotton Bush	*Passiflora foetida*	Stinking Passion	*Solanum seaforthianum*	Brazlilian Nightshade
Andropogon virginicus	Whiskey Grass	*Macroptilium atropurpureum*	Siratro	*Passiflora suberosa*	Corky Passion	*Solanum torvum*	Devils Fig
Asparagus spp.	Asparagus Fern	*Mangifera indica*	Mango	*Phytolacca octandra*	Inkweed	*Strelitzia nicolai*	Giant Bird of Paradise
Bidens pilosa	Cobbler's Pegs	*Megathyrsus maximus*	Guinea Grass	*Pinus elliottii*	Slash Pine	*Syagrus romanzoffiana*	Cocos Palm
Chloris gayana	Rhodes Grass	*Melastoma lepidota*	Melastoma sp.	*Schefflera actinophylla*	Umbrella Tree	*Tetragonia tetragonoides*	New Zealand Spinach
Cirsium vulgare	Spear Thistle	*Melinis repens*	Red Natal Grass				
Crassocephalum crepidioides	Thickhead	*Murraya paniculata*	Mock Orange				

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REFERENCES:

Business Queensland Website - Weeds and diseases (2020)

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CLIENT REF.:	8868	DRAWN:	MC
DRAWING No.:	8868 E AA CRP D2		



Report

Southern Redland Bay WWTP – Mangrove Design and Receiving Environmental Assessments for the Infrastructure Designation Process

Lendlease Communities (Shoreline) Ltd

11 February 2021

Document Status

Version	Doc type	Reviewed by	Approved by	Date issued
1	Final Report	T.McAlister	T.McAlister	2/9/2020
2	Revision	T.McAlister	T.McAlister	29/10/2020
3	Revision	T.McAlister	T.McAlister	11/02/2021

Project Details

Project Name	Southern Redland Bay WWTP – Mangrove Design and Receiving Environmental Assessments for the Infrastructure Designation Process
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Document Number	20020099_R01v05

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CONTENTS

1 INTRODUCTION 8

2 BACKGROUND 11
2.1 Logan-Albert Catchment 13
2.2 Water Quality in the Logan Estuary 15
2.3 The Southern Redland Bay Wastewater Treatment Project Site 18

3 PROOF OF CONCEPT 20
3.1 Literature Review and Case Studies 20
3.1.1 Mangrove Creation, Rehabilitation and Restoration - Case Studies 20
3.1.2 Mangroves in WWTP Effluent Receiving Environments – Case Study 26
3.2 The Southern Redland Bay WWTP Recycled Water Strategy 30
3.3 Nutrient Removal Rates and Offsets 32
3.3.1 Offset Options 32
3.3.2 Discharge from the Wastewater Treatment Plant 35
3.3.3 Mangrove and Salt Marsh Nutrient Offset 36
3.3.4 Sewage Bypass 38
3.4 The Ecological Mangrove Rehabilitation/Restoration (EMR) Protocol 38
3.5 Stage 2 Assessments 41

4 ENVIRONMENTAL VALUES AND WATER QUALITY OBJECTIVES 43

5 THE STATE PLANNING POLICY 49
5.1 State Interest – Water Quality 49
5.2 Assessment Benchmarks 49

6 MONITORING FOR BASELINE CONDITIONS, METHODOLOGY 51
6.1 Ecosystem Health Monitoring Program (EHMP) 51
6.2 Water Quality Monitoring 51
6.3 Hydrodynamic Monitoring 55
6.3.1 Discharge Transects 55
6.3.2 Water Level Loggers 58

7 MONITORING FOR BASELINE CONDITIONS, RESULTS 59
7.1 Physico-Chemical Parameters 59
7.2 Heavy Metals 61
7.3 Pharmaceuticals and Personal Care Products (PPCPs) 62
7.4 Endocrine Disrupting Compounds (EDC) 62
7.5 Herbicides, Pesticides and Other Constituents 62

8 NUMERICAL MODELLING OF THE LOGAN RIVER ESTUARY 63
8.1 Methodology 63
8.2 Boundary Conditions of the Legacy Model 64
8.2.1 Tides 64
8.2.2 Atmospheric 64

8.2.3 Wastewater Treatment Plants 64
8.2.4 Catchment Inflows 64
8.3 Hydrodynamic Model Calibration 64
8.3.1 Water Level Calibration 64
8.3.2 ADCP transects 65
8.4 Water Quality Model Validation 71
8.5 Discussion 82

9 ESTUARINE IMPACT ASSESSMENTS 84
9.1 Water Quality 84
9.1.1 Overview 84
9.1.2 Salinity 87
9.1.3 Nitrogen 89
9.1.4 Phosphorus 92
9.1.5 Dissolved Oxygen 92
9.1.6 Others 93
9.1.7 Summary 98
9.2 Tidal Prism and Sediment Influx 98
9.2.1 Effect on the Tidal Prism of the Logan Estuary 98
9.2.2 Sediment Influx 100
9.2.3 Summary 100
9.3 Waterborne Pathogens 101
9.3.1 Desktop Assessment 101
9.3.2 Tracer Model Simulations 102
9.3.3 Pathogen Risk Assessment 110
9.4 Emerging Contaminants and Other Constituents of Concern 115
9.4.1 Reference Values Based on Other WWTPs 115
9.4.2 Discussion 116

10 GROUNDWATER 121
10.1 Introduction 121
10.2 Background 121
10.3 Activity A: Mangrove establishment 125
10.4 Activity B: Treated recycled water disposal 125
10.5 Summary 125

11 FLOODING AND STORMWATER 126
11.1 Existing Site Elevations 126
11.2 Flood Hazard Mapping 127
11.3 Developed Case Site Elevations and Expected Tide Levels 127
11.4 Flooding of the Mangrove Offset Area 130
11.5 Flooding of the Freshwater Storage Lagoon and Waste Water Treatment Plant 130
11.6 Sea Level Rise 131

12 WATER QUALITY MONITORING AND MANGROVE MANAGEMENT PLAN CONSIDERATIONS 133
12.1 General Considerations 133
12.2 Monitoring Program 133
13 CONCLUSIONS AND RECOMMENDATIONS 137
13.1 Conclusions 137
13.2 Recommendations 137
14 PRE-LODGEMENT COMMENTS AND RESPONSES 138
15 REFERENCES 146

APPENDICES

Appendix A Known Cases of Mangrove Restoration and Rehabilitation
Appendix B Baseline Water Quality - Part A: Metals and Trace Elements
Appendix C Baseline Water Quality - Part B: Pharmaceuticals and PPCPs
Appendix D Baseline Water Quality – Part C: Endocrine Disrupting Compounds
Appendix E Baseline Water Quality – Part D: Herbicides
Appendix F Baseline Water Quality – Part E: Pesticides
Appendix G Baseline Water Quality – Part F: PCBs
Appendix H Proposed recycled water effluent quality
Appendix I Academic Assessments
Appendix J GHD Peer Review
Appendix K Coastal Processes
Appendix L State Planning Policy

LIST OF FIGURES

Figure 2-1 Proposed Site Configuration 12
Figure 2-2 Preclearing vs Existing State of Vegetation coverage in the Logan Catchment (Source: Wetland Info, DES) 14
Figure 2-3 Sewage Treatment Facilities Upstream of the SRBWWTP site 16
Figure 2-4 SRBWWTP Site along the Logan River 19
Figure 3-1 Hydrologic Mangrove Restoration Project at West Lake Park, HollyWood, FL, USA (a) July 1989 (B) November 1991 and (C) January 1996. No Planting of Mangroves occurred 21
Figure 3-2 Locality Map showing the mangrove rehabilitation area and former Serpentine Creek in the area of the New Brisbane airport (Source: Saenger, 1996) 22
Figure 3-3 Bulimba-Oxbow Mangrove Rehabilitation Project Progress - Aerials of the Site in 2010 (Top) and 2017 (Bottom) 24
Figure 3-4 Hydrological Restoration implemented in Tamil Nadu, India, Showing Original Main and Feeder Channels Excavated Circa 1996. Site in march 2003 (above) and Site in January 2016 (Below) (Source: GooGle Earth) 25
Figure 3-5 Mount St John REMP Sites 28
Figure 3-6 TN concentrations in the receiving environment of Mount St John STP 29
Figure 3-7 TP concentraitons in the receiving environment of Moutn St John STP 30

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

Figure 3-8 Offset options based on the Environmental Protection (Water and Wetland Biodiversity) Policy 2019. 35
Figure 3-9 Proposed Site for Mangrove Establishment Circa 2004 (Top) and 2019 (Bottom) showing Natural Mangrove Propagation (Source: Google Maps) 40
Figure 3-10 SRBWWTP Mangrove Conceptual Design Plan (Note: This Figure is illustrative only) 42
Figure 4-1 Environmental Values (EVs) for Logan River Catchments relating to the Site (Source : EPP (Water) 2009) 44
Figure 4-2 Environmental Protection (Water) Policy 2009 – Logan River and Tributaries 45
Figure 4-3 Environmental Protection (Water) Policy 2009 (Extract) – The Site 46
Figure 6-1 EHMP Sites in the Logan River Catchment (marked as Orange Triangles) 52
Figure 6-2 SRBWWTP water quality monitoring sites in relation to EHMP Sites 54
Figure 6-3 M9 unit (upper) and M9 placed in the hydroboard (Source: Sontek 2018) 56
Figure 6-4 ADCP M9 unit during data collection (Example) 57
Figure 6-5 Sensus Ultra Dive Logging Device 57
Figure 6-6 Water level logger mounted onto Besser brick 58
Figure 8-1 TUFLOW FV model mesh for the Logan River 63
Figure 8-2 Comparison of the legacy and improved numerical models against measurements in the upper Logan Estuary at Logan Village (left) and the upper Albert Estuary at Wolffdene (right) 65
Figure 8-3 Downward facing ADCP mounted on an unmanned vessel and towed alongside a field boat 65
Figure 8-4 Comparision between measured and modelled flows through the Logan RIver Estuary adjacent to the MOA 66
Figure 8-5 Comparison between measured and modelled ebb tide currents adjacent to the MOA during neap tides 67
Figure 8-6 Comparison between measured and modelled flood-tide currents adjacent to the MOA during neap-tides 68
Figure 8-7 Comparison between measured and modelled flood-tide currents adjacent to the MOA during spring-tides 69
Figure 8-8 Comparison between measured and modelled ebb-tide currents adjacent to the MOA during spring-tides 70
Figure 8-9 Observed (EHMP) and modelled DO in the Logan Estuary, 2018-2019 71
Figure 8-10 Observed (EHMP) and modelled DO Saturation in the Logan Estuary (2018-2019) 72
Figure 8-11 Observed (EHMP) and modelled Total Nitrogen in the Logan Estuary (2018-2019) 72
Figure 8-12 Observed (EHMP) and modelled Ammonia in the Logan Estuary (2018-2019) 73
Figure 8-13 Observed (EHMP) and modelled NOx in the Logan Estuary (2018-2019) 73
Figure 8-14 Observed (EHMP) and modelled ON in the Logan Estuary (2018-2019) 74
Figure 8-15 Observed (EHMP) and modelled Total Phosphorus in the Logan Estuary, 2018-2019 74
Figure 8-16 Observed (EHMP) and modelled FRP in the Logan Estuary (2018-2019) 75
Figure 8-17 Observed (EHMP) and modelled OP in the Logan Estuary (2018-2019) 75
Figure 8-18 Observed (EHMP) and modelled Turbidity in the Logan Estuary (2018-2019) 76
Figure 8-19 Observed (EHMP) and modelled Chlorophyll-a in the Logan Estuary (2018-2019) 76
Figure 8-20 Observed (EHMP) and modelled Salinity in the Logan Estuary (2018-2019) 77
Figure 8-21 Observed (EHMP) and modelled Temperature in the Logan Estuary (2018-2019) 77
Figure 8-22 Comparison between simulated and measured temperature 78
Figure 8-23 Comparison between Simulated and Measured Salinity 79
Figure 8-24 Comparison between Simulated and Measured Dissolved Oxygen 80

Figure 8-25 Comparison between Simulated and Measured Total Nitrogen 81
Figure 8-26 Comparison between Simulated and Measured Total Phosphorus 82
Figure 9-1 modelled inundation times (percentage) within the MOA. Inundation times beyond the MOA have not been mapped 85
Figure 9-2 Speciation of nutrients within the modelled discharges of the proposed Wastewater treatment plant. Inorganic nutrients are grouped and plotted to the left of the respective organic nutrients. 86
Figure 9-3 Median salinity distribution in the Logan River – Existing (Undeveloped) case 87
Figure 9-4 Box plot of modelled salinity 88
Figure 9-5 Median salinity distribution – Above: Base Case (No Recycled Water discharge), Below: Developed Case (with recycled water discharge) 89
Figure 9-6 Box plot of modelled total nitrogen 90
Figure 9-7 Median Total Nitrogen distribution – Above: Base Case with No RecYcled Water discharge in the MOA; Below: Developed Case with Recycled Water discharge in the MOA 91
Figure 9-8 Box Plot of modelled total phosphorus 92
Figure 9-9 Box plot of modelled dissolved oxygen 93
Figure 9-10 Box Plot of Modelled Ammonia 94
Figure 9-11 Box Plot of Modelled Nitrate and Nitrite N (NOX) 94
Figure 9-12 Box Plot of Modelled Organic Nitrogen (ON) 95
Figure 9-13 Box Plot of Modelled Filterable Reactive Phosphorus (FRP) 95
Figure 9-14 Box Plot of Modelled Orthophosphate (OP) 96
Figure 9-15 Box Plot of Modelled Turbidity 96
Figure 9-16 Box Plot of Modelled Chlorophyll-A[1] 97
Figure 9-17 Box Plot of Modelled Temperature 97
Figure 9-18 Flows (+ve into mangrove site) for the proposed MOA with WWTP recycled water discharge (development case) 99
Figure 9-19 Sediment flux in the proposed Southern Redland Bay Mangroves (development case) 100
Figure 9-20 Typical wet weather flow rates 103
Figure 9-21 Prawn farm intake points 104
Figure 9-22 Bacteria Concentration Results 105
Figure 9-23 Virus Concentration Results 106
Figure 9-24 Cryptosporidium Concentration Results 107
Figure 9-25 Dry Weather Log Reductions 108
Figure 9-26 Wet Weather Log Reductions 109
Figure 9-27 Approach for defining treatment requirements in the Australian Guidelines for Water Recycling (Cunliffe and Petterson 2019) 111
Figure 9-28 Log10 reductions required as a function of volumes exposed (reproduced from AGWR Figure A2.1). Upper line represents bacteria and protozoa, lower line is for viruses 112
Figure 9-29 Significance of WWTP release driving virus risk under different contributions of background water quality 114
Figure 10-1 Locations of registered groundwater wells shown as blue dots (Source: Queensland Globe) 122
Figure 10-2 Location of potential aquatic GDEs, showing area of moderate potential for aquatic GDEs in alluvial aquifers in purple (Source: Queensland Globe) 123
Figure 10-3 Location of potential terrestrial GDEs listed as moderate potential GDEs in alluvial aquifers in green (Source: Queensland Globe) 124
Figure 11-1 Existing Site Elevations 126
Figure 11-2 Redland City Flood and Stormtide Overlay 128

Figure 11-3 Existing Site Elevations 129
Figure 11-4 Proposed Elevations 130
Figure 11-5 Southern Redland Bay WWTP – Concept Rehabilitation PLan Management Zone 132

LIST OF TABLES

Table 2-1 Logan-Albert Drainage Basin Wetland Change by System 13
Table 2-2 Sewage Treatment Facilities Upstream of the SRBWWTP site (Source: Wetland Info, DES) 17
Table 3-1 Summary of recycled water quality 30
Table 3-2 Average Annual Wastewater Volume under adopted strategy (Years 1 to 6) 31
Table 3-3 Estimated population and average daily flows and nutrient loads 36
Table 3-4 Nutrient Removal Rates in Mangroves and Salt Marshes 37
Table 3-5 Area required for the mangroves and estimated nutrient uptake 37
Table 4-1 Site-specific Water Quality Objectives to protect Aquatic Ecosystems (Source: EPP (Water) 2009) 47
Table 6-1 Hydrodynamic monitoring 55
Table 6-2 Instrument specification for the M9 ADCP 55
Table 7-1 General Water Quality 60
Table 9-1 Modelled removal of nutriens within the MOA for developed case 85
Table 9-2 Tidal Prism Calculations 99
Table 9-3 Design and modelled Log10 reductions for treatment barriers/controls at Southern Redland Bay under dry weather conditions. 112
Table 9-4 Critical consumption volumes to maintain tolerable risk with existing control measures 113
Table 9-5 Toxicants (Metals) 118
Table 12-1 Monitoring Program (MOA and FSL) 135
Table 12-2 Water Quality Monitoring Checklist (MOA and FSL) 136
Table 14-1 Responses to DES Comments 139
Table 14-2 Responses to DAF Comments 141

1 INTRODUCTION

The Southern Redland Bay development area is the name given to the area to the south of Redland Bay that is to be developed in accordance with the South East Queensland Regional Plan (SEQRP). A major part of the expansion area is the proposed Shoreline Development, a master planned community being developed by Lendlease with a planned population of up to 10,000 equivalent persons (EP). Also servicing the area surrounding the Shoreline development will increase the total connected population to approximately 13,500 EP.

The proposed Southern Redland Bay Wastewater Treatment site is located to the south of 38 Longland Road, Redland Bay, on an outer bend of the Logan River, about 7.5 km upstream from the mouth of the river. The site extends over four (4) lots within Redland City Council, bearing lot numbers 3RP223470, 2RP223470, 254S31102 and 1SL3427.

In the course of studies regarding the treatment and disposal solution for the proposed Southern Redland Bay Wastewater Treatment Plant, an opportunity was identified to acquire a parcel of land south of Longland Road

The concept was raised of using this land to construct an area (via earthworks/excavation) where a new mangrove forest will be established in order to:

- 'Polish' the recycled water from the proposed wastewater treatment plant; and
- 'Offset' the nutrient load through nitrogen retention/de-nitrification (with the added benefit of offsetting carbon as a carbon sink).

Additional benefits of the area will include:

- Further nutrient offset through sediment accretion in the mangroves;
- Mitigating the effects of sea level rise;
- Mitigating the effects of flooding; and
- Erosion prevention.

This report, together with pre-lodgement discussions with the ID Team and other State agencies, has been developed based on extensive research and analysis, feedback from expert researchers, recommendations from the Department of Agriculture and Fisheries (DAF) and Department of Environment and Science (DES), an independent review by GHD and advice from Redland City Council which formed the basis for the initial option selection process.

Prior to this report, Water Technology, in partnership with staff from frc environmental, CSIRO, Douglas Partners, Saunders-Havill Group, the University of Queensland and Griffith University, undertook due diligence assessments to inform the project and develop a thorough understanding of the processes involved in the design, construction and maintenance of the proposed mangrove system. The due diligence assessments were conducted in two stages:

- **Stage 1 - Conceptual design development**

Stage 1 aimed to address key questions identified as being critical in assessing the feasibility of the proposed work in forming the baseline for the required due diligence assessments to follow; these being:

  - Will the mangroves/saltmarsh grow and where has this been done before?
  - Will they remove nutrients from the proposed Wastewater Treatment Plant?
  - Are there any established procedures/guidelines?

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

In preparing the detailed conceptual design (Stage 1), Water Technology conducted an extensive review of available literature based on real-world applications involving the construction/rehabilitation of mangrove wetlands and their associated nutrient removal efficiencies. A thorough understanding was developed of the processes involved (with advice from experts in associated fields), including hydraulic and hydrological works that are necessary to create an effective mangrove habitat which will also provide a nutrient removal/offset function. Estimated nutrient removal rates were then used to determine the required sizing of the proposed mangrove wetlands.

- **Stage 2 - Due diligence assessments (of the above concept)**

Stage 2 involved several comprehensive, well-informed and targeted due diligence assessments based on the preferred layout and configuration of the mangrove wetland system that was developed and refined over the course of the (Stage 2) assessments, building on the preliminary findings from Stage 1.

The due diligence assessments undertaken considered the following key issues:

- Mangrove establishment;
- Viruses;
- Mosquitoes;
- Coastal Processes;
- Water quality;
- Hydrology;
- Flora and Fauna; and
- Geotechnical constraints - including testing for acid-sulphate soils.

The findings of the due diligence assessments informed the project and guided key design recommendations to further develop the proposed concept. Learnings from Stages 1 and 2 were adapted to the eventual refinement of the conceptual design and were integrated and updated as the project advanced to Stage 3 (the current stage). Stage 2 works were appraised by independent reviewers from GHD and academics from Griffith University and the University of Queensland (See Appendix I and Appendix J for associated documents).

- **Stage 3 – Assessments for the Infrastructure Designation Process**

This report comprises Stage 3 of the suite of assessments conducted to date towards achieving a detailed design of the mangrove forest, which is also referred to as the Mangrove Offset Area (MOA), and its ancillary infrastructure. Where required, the report incorporates outcomes and learnings from Stages 1 and 2 and in some cases, presents improved and refined outcomes to the analyses conducted in Stage 2.

Stage 3 verifies the ability of the MOA and its ancillary infrastructure to offset recycled water discharges from the Southern Redland Bay WWTP such that there will be no adverse water quality or public health impacts on the Logan River or Southern Moreton Bay. Ancillary infrastructure includes a Freshwater Storage Lagoon (FSL) which will be created by modifying an existing freshwater body within the site.

Water Technology has undertaken detailed assessments of the works associated with the proposed Southern Redland Bay WWTP as required by the Infrastructure Designation (ID) process, which this report helps address. These works address key concerns associated with matters regarding impacts on the receiving environment and other potential impacts of the site.

The report is structured as follows:

- Background (Section 2);
- Proof of Concept (Section 3);
- Environmental Values and Water Quality Objectives (Section 4);
- Overview of the State Planning Policy (Section 5);
- Monitoring for Baseline Conditions, Methodology (Section 6);
- Monitoring of Baseline Conditions, Results (Section 7);
- Numerical Modelling of the Logan River Estuary (Section 8);
- Estuarine Impact Assessments (Section 9);
- Groundwater (Chapter 10);
- Flooding and Stormwater Management (Chapter 11);
- Water Quality Monitoring and Mangrove Management Plan (Section 12); and
- Conclusions and Recommendations (Section 13).

The report concludes with proposed site-based management considerations for the Southern Redland Bay WWTP site that will either maintain existing conditions in the Logan River, or add benefit. The water quality management plan for the site, which is intended to be a working document, is to be used in the development/rehabilitation and management of the MOA and FSL to support and maintain defined objectives in minimising environmental harm as set out in the State Planning Policy (SPP) 2017.

2 BACKGROUND

Most of the proposed land for the Shoreline development lies in the State Government's 'Urban Footprint' regional land use category within the current South East Queensland Regional Plan (SEQRP). Initial assessments of sewer servicing options for the Shoreline development undertaken by Stantec identified that Council's existing sewage infrastructure network does not have the treatment capacity for Shoreline or the wider Southern Redland Bay catchment. In addition, upgrading existing facilities is not an option due to receiving environment assimilative capacity limitations.

Consequently, a new sub-regional sewer infrastructure solution is proposed which will ultimately service approximately 13,500 Equivalent Persons (EP). As part of an extensive scoping phase associated with this solution, options for location of the recycled water discharge were investigated by Stantec and Water Technology, which eventually resulted in a sewer infrastructure solution that comprises a standalone, greenfield wastewater treatment plant and a land-based recycled water discharge.

The land upon which the proposed greenfield infrastructure is to be located is to the south of Beenleigh-Redland Bay Road at Carbrook (Figure 2-1), on an outer bend of the Logan River, about 7.5 km upstream from the mouth of the river. The site extends over 4 lots within Redland City Council. Adjacent to the lots, on the western side, is Logan City Council, at the southern end is the Logan River, rural property is on the eastern side and the northern side of the area is adjacent to the Beenleigh Redland Bay Road. Upon undertaking preliminary investigations, the potential for the land to house the Southern Redland Bay WWTP was recognised. The land has also been identified as a well-suited opportunity for the construction of a tailored facility to offset the nutrient discharge from the WWTP by creating a new mangrove forest and salt-marsh habitat to further treat recycled water discharges.

The proposed mangrove forest option is as an alternative to constructing a recycled water outfall into Southern Moreton Bay. The mangroves will offset nutrients from the Logan River and wastewater treatment plant through nitrogen retention/de-nitrification and phosphorus capture and storage (with the added benefit of offsetting carbon as a carbon sink) as an alternative to constructing an outfall into Southern Moreton Bay.

Therefore, the proposed Southern Redland Bay WWTP development in its entirety (Figure 2-1) involves the designation of land at 38 Longland Road, Redland Bay; including the following activities:

- Construction of the main Wastewater Treatment Plant;
- Modification of an existing freshwater body to create Freshwater Storage Lagoon (FSL);
- Creation of a Mangrove Offset Area (MOA) comprising 8.7 ha of mangroves and approximately 1.1 ha of surrounding saltmarsh; and
- Ancillary infrastructure to support the WWTP.

The WWTP will service land within the urban footprint of the Southern Redland Bay area and not just that within the Shoreline landholding. The Southern Redland Bay WWTP (SRBWWTP) will be an exemplar of best practice in recycled water management, and will have ancillary benefits such as carbon sequestration, the provision of fish and bird habitat and the delivery of a net improvement in water quality in the Logan River Estuary.

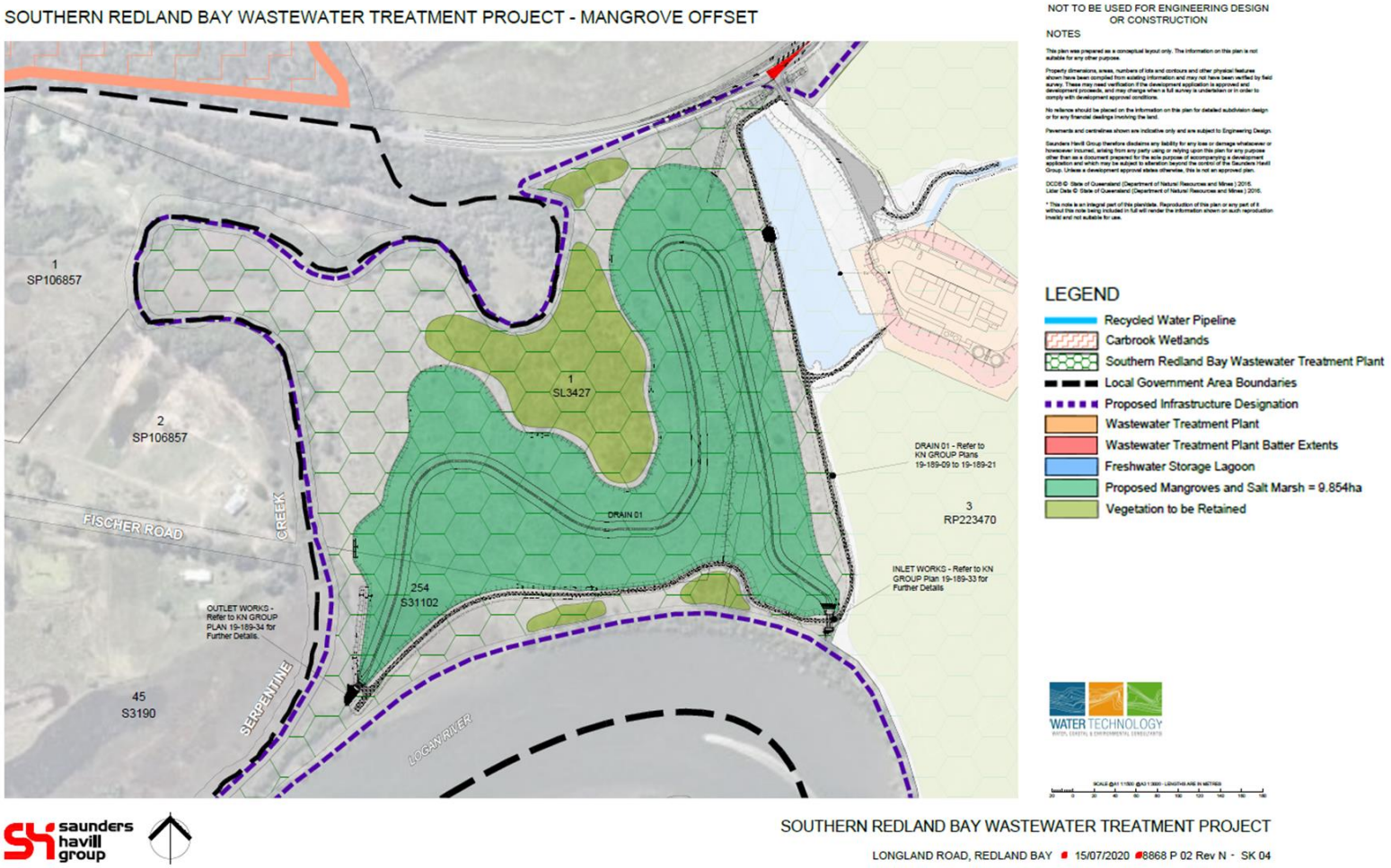


FIGURE 2-1 PROPOSED SITE CONFIGURATION

2.1 Logan-Albert Catchment

The SRBWWTP is located within the Logan-Albert drainage basin which covers a total area of 4,150 km^2, wherein the Logan catchment alone covers approximately 2,000 km^2. Of the total basin area, in 2017 122 ha was covered by wetlands, having gradually increased by over 10% since 2001 (see Table 2-1). The main waterway is the Logan River, with numerous smaller waterways flowing into it. The Logan River is joined by the Albert River near Eagleby (11 kilometres upstream of its mouth) and then flows into Southern Moreton Bay. The site is located within the Lower Logan sub catchment area, which is well within the tidal reaches of the Logan River Estuary.

TABLE 2-1 LOGAN-ALBERT DRAINAGE BASIN WETLAND CHANGE BY SYSTEM

Logan-Albert Drainage Basin	2017	2013	2009	2005	2001
Total Area (km^2)	4149.9	4149.8	4149.8	4149.8	4149.8
Total Wetland Area (km^2)	121.8	121.6	111.2	109.8	109.0
Artificial and highly modified	31.1	31.0	19.4	17.5	16.5
Estuarine	21.5	21.5	21.5	21.5	21.5
Lacustrine	1.8	1.6	1.5	1.5	1.3
Palustrine	34.7	34.8	34.8	35.3	35.6
Riverine	32.8	32.8	34.0	34.1	34.1

Historically, most of the headwaters of the Logan catchment comprised large areas of rainforest and scrub, together with wet eucalypt forests. The lower catchment area (where the site is located) comprised large areas of melaleuca woodlands, together with wet eucalypt and mangrove forests, which made up the preclearing vegetation condition of the region (Figure 2-2).

Although the current vegetation cover of the headwaters is largely intact with large areas of rainforest and scrubs and eucalypt vegetation across the upper catchment, most of the mid and lower catchment has been cleared for a range of rural land uses (particularly for grazing and residential), and sand and hard rock extraction. The lower reaches, especially those in the Lower Logan sub-catchment area, have been heavily developed and therefore have many impermeable surfaces. Over the course of time, these developments and activities in the lower sub-catchment have changed the shape of the landscape of the region and understandably modified water flow patterns. Although buildings and other important infrastructure such as roads, railways and creek crossings are necessary for development in the region, they have been contributory to creating impermeable surfaces and barriers that redirect water through single points or culverts, leading to channelling of water, thus increasing the rates of flow of water and the potential for erosion.

The geology of the Lower Logan sub-catchment includes relatively impervious fractured metamorphic rocks, impervious rocks, low porosity sandstones, alluvium, sand and other unconsolidated sediments. Runoff from the lower porosity rock areas flows into floodplain alluvium and this groundwater is held up by the underlying impervious rock. This groundwater supports wetlands and maintains stream flows in the sub-catchment.

Due to low topography, the high volume of localised runoff from low porosity rocks and from the large catchment upstream, backing up of flood waters where the Albert meets the Logan River, and backing up of tidal waters, the Lower Logan sub-catchment is prone to flooding.

Despite being highly modified due to historical clearing, there are areas of remnant eucalypt forests and woodlands and mangroves near the mouth of the Logan River, with large areas of regrowth being apparent. These areas provide habitat for protected marine plants such as mangroves (e.g. the grey mangrove,

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

Avicennia marina), saltmarsh and seagrasses, which in turn support the local fauna including fish and migratory birds. The estuary supports an active prawn and fishing industry, and there are several aquaculture facilities on the banks of the Logan River near its mouth.

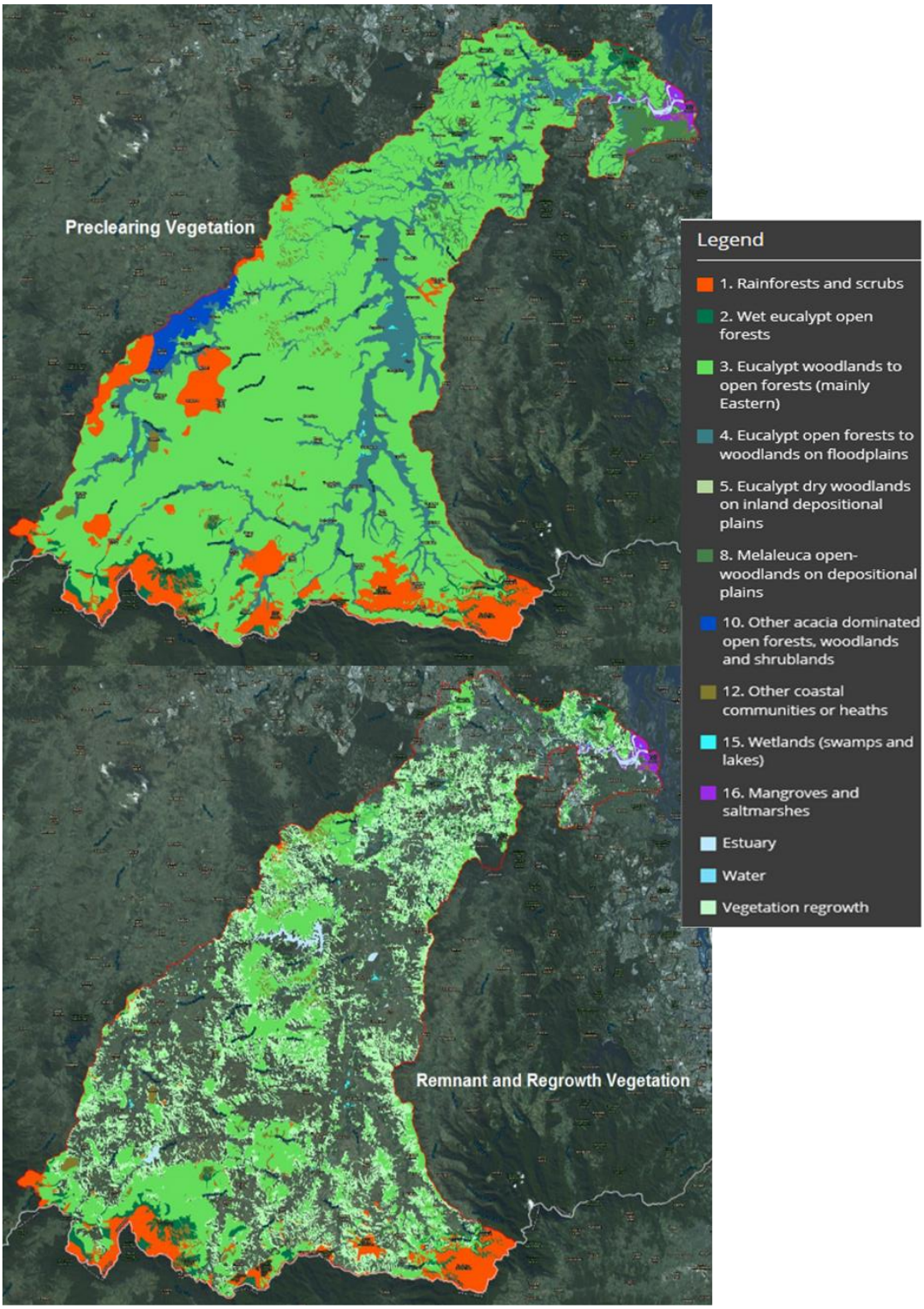


FIGURE 2-2 PRECLEARING VS EXISTING STATE OF VEGETATION COVERAGE IN THE LOGAN CATCHMENT (SOURCE: WETLAND INFO, DES)

2.2 Water Quality in the Logan Estuary

In the Lower Logan sub-catchment, water quality is heavily influenced by land use, including stormwater runoff. Water quality is also heavily influenced by point source inputs such as sewage treatment plants, septic tank seepage and stormwater discharge. In the overall Logan sub-catchment, there are several sewage treatment plants, including Kooralbyn, Boonah, Beaudesert, Flagstone, Jimboomba, Eagleby, Loganholme and Mount Cotton, all of which discharge directly or indirectly into the Logan River (Figure 2-3 and Table 2-2). Of these, the Lower Logan sub-catchment treatment plants at Loganholme (> 100,000 EP capacity) and Mount Cotton (10,000 – 50,000 EP capacity) discharge into the Logan River and the Beenleigh Water Reclamation Facility (50,000 – 100,000 EP capacity) discharges into the Albert River. Although DES reports that the Loganholme STP alone services >100,000 EP, according to Logan City Council factsheets the capacity of the treatment plant is as follows:

- As of 2011, the plant serviced 196,596 EP;
- As of 2016, the predicted equivalent population serviced was estimated to be 201,671 EP; and
- Upon the imminent 'Stage 7' upgrade (expected to be around 2024), the predicted equivalent population that will be serviced by the plant is 335,000 EP (67 ML/day, equivalent to 200 L/EP/day).

Similarly, according to Logan City Council factsheets, the capacity of the Beenleigh treatment plant is as follows:

- Average dry weather flow as of 2012 was 12.5 ML/day, servicing 46,000 EP; and
- Maximum capacity (presumably for the same time period) was 15 ML/day, with the ability to service 60,000 EP (based on 250 L/EP/day).

Considering the above numbers, at full capacity, the combined total peak daily design capacity of the Loganholme and Beenleigh treatment plants is approximately 495,000 EP, equivalent to 82 ML/day. If the maximum discharge capacity from the Mount Cotton[1] plant was also considered (50,000 EP), and upon assuming a discharge rate of 200 L/EP/day, the total daily discharge can be estimated to be 10 ML/day. Therefore, the combined discharge from the three sewage treatment plants is expected to be ~ 92 ML/day, with release points for all three plants located within 17 km of the mouth of the Logan River Estuary.

Due to the existing discharges and other influences (e.g. urban stormwater runoff), the estuarine reaches of the Logan-Albert sub-catchment can experience poor water quality conditions, including high turbidity, high nutrient concentrations and low dissolved oxygen. The turbidity of the lower Logan River appears to be related to sediment inputs from the catchment and tidal interactions.

[1] Note that the actual discharge volumes from the Mount Cotton STP could vary from estimates in Table 2-2 (Wetland Info, DES) as it is unclear how much recycled water is allocated to irrigation at the local golf course and how much excess recycled water is discharged.

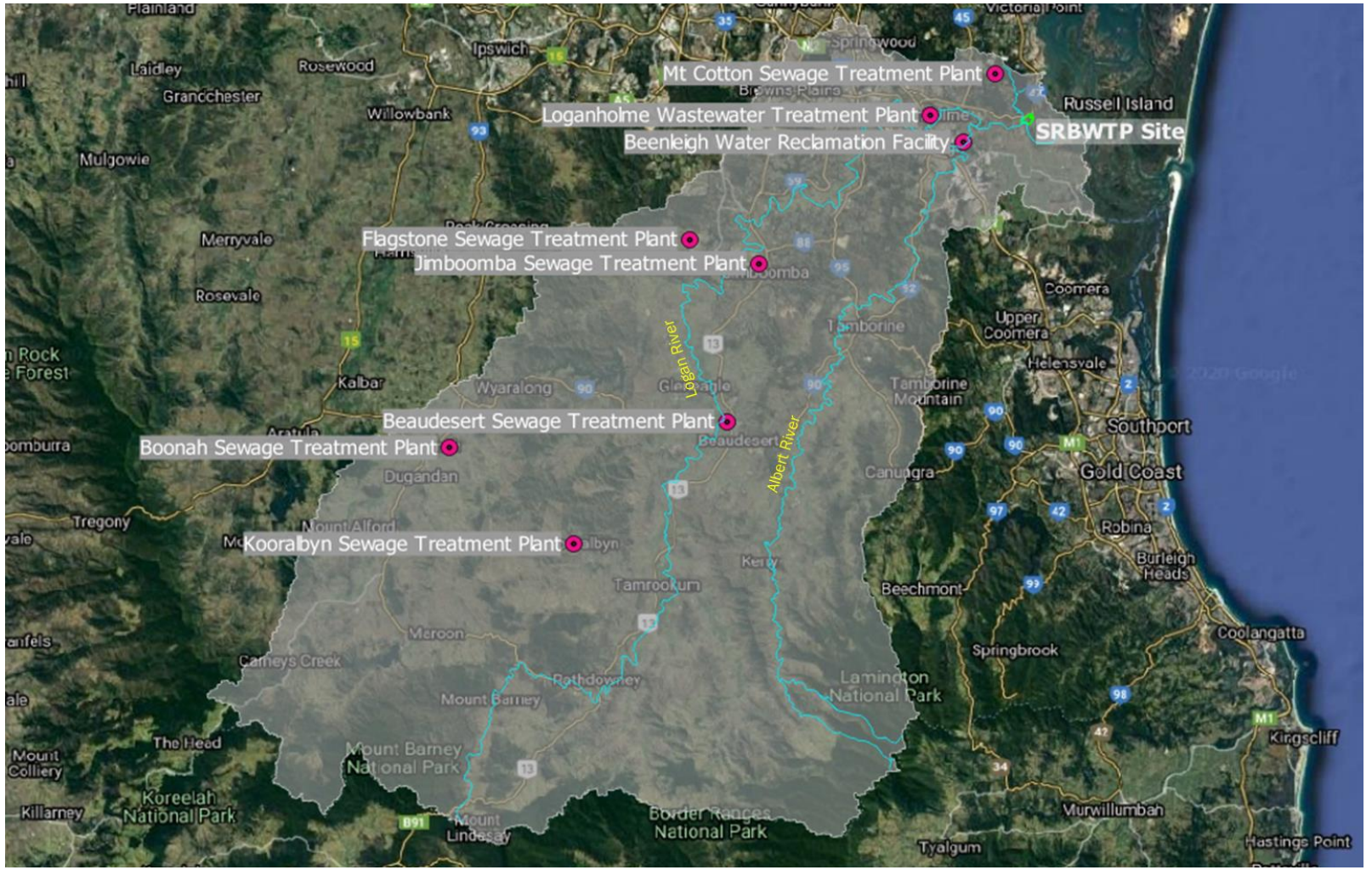


FIGURE 2-3 SEWAGE TREATMENT FACILITIES UPSTREAM OF THE SRBWWTP SITE

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

TABLE 2-2 SEWAGE TREATMENT FACILITIES UPSTREAM OF THE SRBWWTP SITE (SOURCE: WETLAND INFO, DES)

Facility	Lat-Long of Facility and Release Points	Release	Status	Approval Holder	Total Daily Peak Design Capacity	Basin	Stream
Mt Cotton STP (German Church Road, Mt Cotton)	Facility: -27.6462, 153.261 RP: -27.68467, 153.25072	Discharge via impoundment on Carbrook Golf Club to waters described as the Logan River at 10.5 km AMTD*	Operational	Redland City Council	10,000 – 50,000 EP	Logan-Albert	Logan River
Loganholme WWTP (97 Chetwynd Street, Loganholme)	Facility: -27.685, 153.196 RP: -27.6871, 153.2034	Discharge via outfall pipe located on the Logan River at approx. 17 km AMTD	Operational	Logan Water	>100,000 EP**	Logan-Albert	Logan River
Beenleigh Water Reclamation Facility (293 and 319 Logan Street, Eagleby)	Facility: -27.7102, 153.2289 RP: -27.71162, 153.22953	Effluent discharged via overflow weir of effluent pond to Albert River at 4 km AMTD	Operational	Logan Water	50,000 – 100,000 EP	Logan-Albert	Albert River
Jimboomba Sewage Treatment Plant (35 Matt Court, Jimboomba)	Facility: -27.82333, 153.02194 RP: -27.82299, 153.02176	Irrigation of treated effluent to land	Operational	Logan Water	1,500 – 4,000 EP	Logan-Albert	Logan River
Flagstone Sewage Treatment Plant (Red Cedar Crescent, Flagstone Creek)	Facility: -27.80065, 152.95182 RP: -27.8043, 152.9387	Land irrigation to council property Lot 2 RP47120, Lot 907 and 908 RP819216	Operational	Logan Water	1,500 – 4,000 EP	Logan-Albert	N/A
Beaudesert STP (Drumley Street, Beaudesert)	Facility: -27.97045, 152.98954 RP: -27.96978, 152.98661	Release of treated sewage effluent to Logan River at approx. 105 km AMTD	Operational	Queensland Urban Utilities	4,000 – 10,000 EP	Logan-Albert	Logan River
Kooralbyn Sewage Treatment Plant (8-22 Etruscan Road, Kooralbyn)	Facility: -28.0847, 152.8334 RP: -28.08375, 152.83493	Discharge to trench and irrigation.	Operational	Queensland Urban Utilities	100 – 1,500 EP	Logan-Albert	Logan River
Boonah Sewage Treatment Plant (Gorkow Road, Boonah)	Facility: -27.99481, 152.7072 RP: -27.9987, 152.7079	Sewage wastes from the treatment plant to Teviot Brook. Not a continuous release	Operational	Queensland Urban Utilities	1,500 – 4,000 EP	Logan-Albert	Logan River

*AMTD – Adopted Middle Thread Distance

**Actual values may be much higher. Logan City Council estimates the capacity upon stage 7 upgrade to be 335,000 EP.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

2.3 The Southern Redland Bay Wastewater Treatment Project Site

The proposed SRBWWTP site is located to the south of 38 Longland Road, Redland Bay, on an outer bend of the Logan River, about 7.5 km upstream from the mouth of the river (Figure 2-4). The site is approximately 75 hectares (ha) in area and extends over four (4) lots within the Redland City Council, bearing lot numbers 3RP223470, 2RP223470, 254S31102 and 1SL3427. It is proposed that the project will consist of a Mangrove Offset Area (MOA) and Freshwater Storage Lagoon (FSL), and an adjacent WWTP to the east of the site. Adjacent to the lots, on the western side, is Logan City Council, at the southern end is the Logan River, rural property is on the eastern side and the northern side of the area is adjacent to the Beenleigh Redland Bay Road. The Southern Redland Bay WWTP will service 13,500 EP, this being some 5% of the population ***already*** being serviced by existing sewage treatment facilities in the Lower Logan sub-catchment, without considering the five other facilities elsewhere in the catchment.

The proposed development footprint (where the MOA, FSL and WWTP are to be located) is located on land which has been subject to broadscale clearing and predominately reflects open paddock. The balance of land within the site contains areas of higher ecological value. Regrowth and remnant bushland to the east provides suitable habitat for terrestrial fauna species. Patches of Casuarina Glauca are present along the banks of the Logan River and Serpentine Creek which can provide diverse habitat for a range of wetland, grassland, and woodland fauna species. Mangroves and saltmarsh dominate tidally influenced areas and the banks of the Logan River and Serpentine Creek and provide habitat for fish and aquatic species and foraging habitat for migratory birds.

The Department of Environment and Science (DES) notes that Queensland's estuarine and marine ecosystems (wetlands) support much of the state's native biodiversity, including migratory birds and fish. Queensland's wetlands are also important as they provide nurseries for fish and help protect people and property from storm surges. They also protect downstream habitats by removing sediments and transforming nutrients and pesticides, which is particularly crucial for the health of Queensland's Great Barrier Reef.

Taking the various benefits of wetlands into consideration and acknowledging their proven ability to improve water quality and backed by a strong scientific understanding of the processes involved, the proposed development is expected to either maintain existing conditions in the Logan River Estuary or add benefit to the surrounding environment. It is proposed, in addition to transforming nutrients and providing a barrier for erosion and storm tide events, that the development will add to the net wetland area in the estuarine reaches of the Logan-Albert Drainage basin, thus providing the added benefit of creating a suitable habitat for various species of flora and fauna in the region.

This report addresses the water quality concerns of the proposed development using monitoring data to assess the baseline conditions of the Logan River followed by assessments of the impacts of the development on the environmental values of the Logan River.

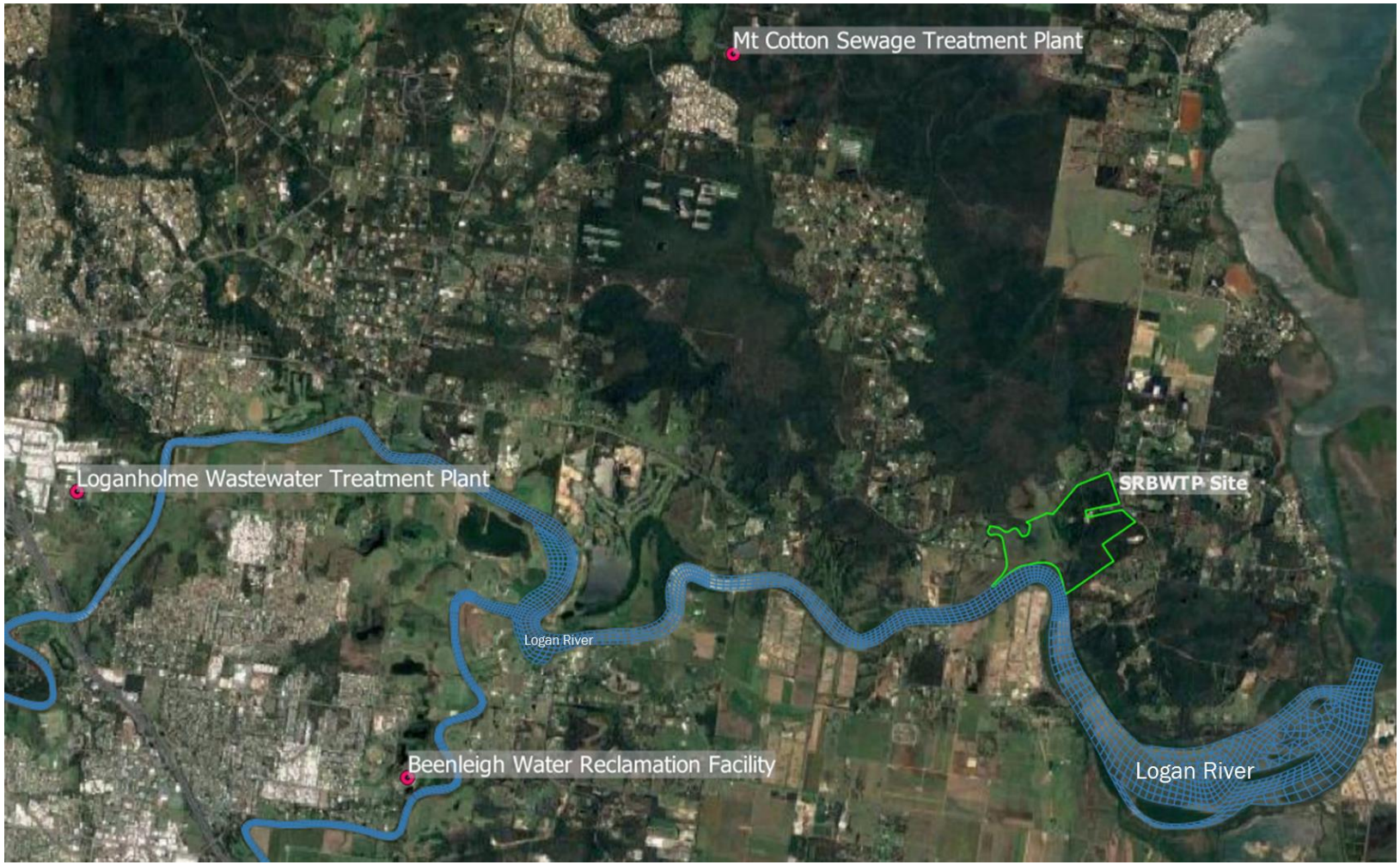


FIGURE 2-4 SRBWWTP SITE ALONG THE LOGAN RIVER

3 PROOF OF CONCEPT

Section 3 of this report contains excerpts of background research and assessments conducted in Stage 1 (Sections 3.1 - 3.4) and Stage 2 (Section 3.5). See Section 1 for a summary on the stages involved.

3.1 Literature Review and Case Studies

The literature presented in this report was reviewed upon advice and guidance from experts in various fields associated with mangrove ecology, establishment, growth, and maintenance. They included academics and industry (field) experts alike, who have been involved in several mangrove restoration, rehabilitation, and establishment projects across South East Queensland. In the context of mangrove establishment, it is important to note the general terminology associated with such works. 'Restoration' refers to the act of bringing an ecosystem back into, as nearly as possible, its original condition, renewing it or bringing it back into use (Field, 1996). 'Rehabilitation' denotes any activity, including restoration and habitat creation, which converts a degraded system to a stable alternative (Stevenson et al., 1999). Unfortunately, mangrove rehabilitation (which is an important part of the proposed SRBWWTP) has often been carried out simply by planting mangrove seedlings without adequate site assessments, or subsequent evaluation of the success of planting at the ecosystem level (Field, 1996), which has led to misconceptions about the efficacy of similar schemes.

Significant potential exists to rehabilitate mangrove forests through the application of basic principles of ecological restoration using ecological engineering approaches prior to design and construction (Lewis III, 2005). Getting the right soil elevations, and in turn the hydrology of the system correct, are the two key requirements for the establishment of mangroves. Assessing the existing hydrology of natural extant mangrove ecosystems, and applying this knowledge to firstly protect existing mangroves, and to secondly achieve successful and cost-effective ecological restoration, is important. Previous research has widely documented the general principle that mangrove forests worldwide exist largely in a raised and sloped platform above mean sea level and which is inundated for approximately 30% or less of the time by tidal waters. Although the translation of known research into real-life mangrove restoration and rehabilitation has been limited, in cases where research has been accounted for (by qualified experts) and results documented, the viability of such projects has been visibly positive.

Leading mangrove experts have recently proposed the further development of available protocols for mangrove restoration/rehabilitation under the specific conditions at each individual location (J. López-Portillo et al., 2017). Some of these experts, Dr. Fernanda Adame and Dr. Alistair Grinham, were consulted concerning the development of the SRBWWTP mangrove plan. The protocol being used for the plan is closely associated with (if not, in deeper detail than) the Ecological Mangrove Rehabilitation/Restoration or EMR (Lewis and Marshall, 1998; Stevenson et al., 1999) protocol, which is a six-step process (listed in Section 3.4) which has been implemented at a number of successful sites around the world (Lewis and Brown, 2014). Some of these are documented below.

3.1.1 Mangrove Creation, Rehabilitation and Restoration - Case Studies

West Lake, Florida - Figure 3-1 shows a time sequence over a period of 78 months from the completion of a portion of the hydrologic restoration of a 500 ha mangrove restoration site at West Lake near Fort Lauderdale, Florida. The procedure involved the excavation of historically filled-in mangrove wetlands. Success resulted from using the adjacent undisturbed forest as a reference site to achieve final constructed grades (elevations). Extensive constructed tidal creeks were also added to the original plans, which had been designed without them. No planting of mangroves took place or was necessary. The hydrologic restoration reconnected impounded mangroves to normal tidal influence (Lewis III, R.R., 2005).

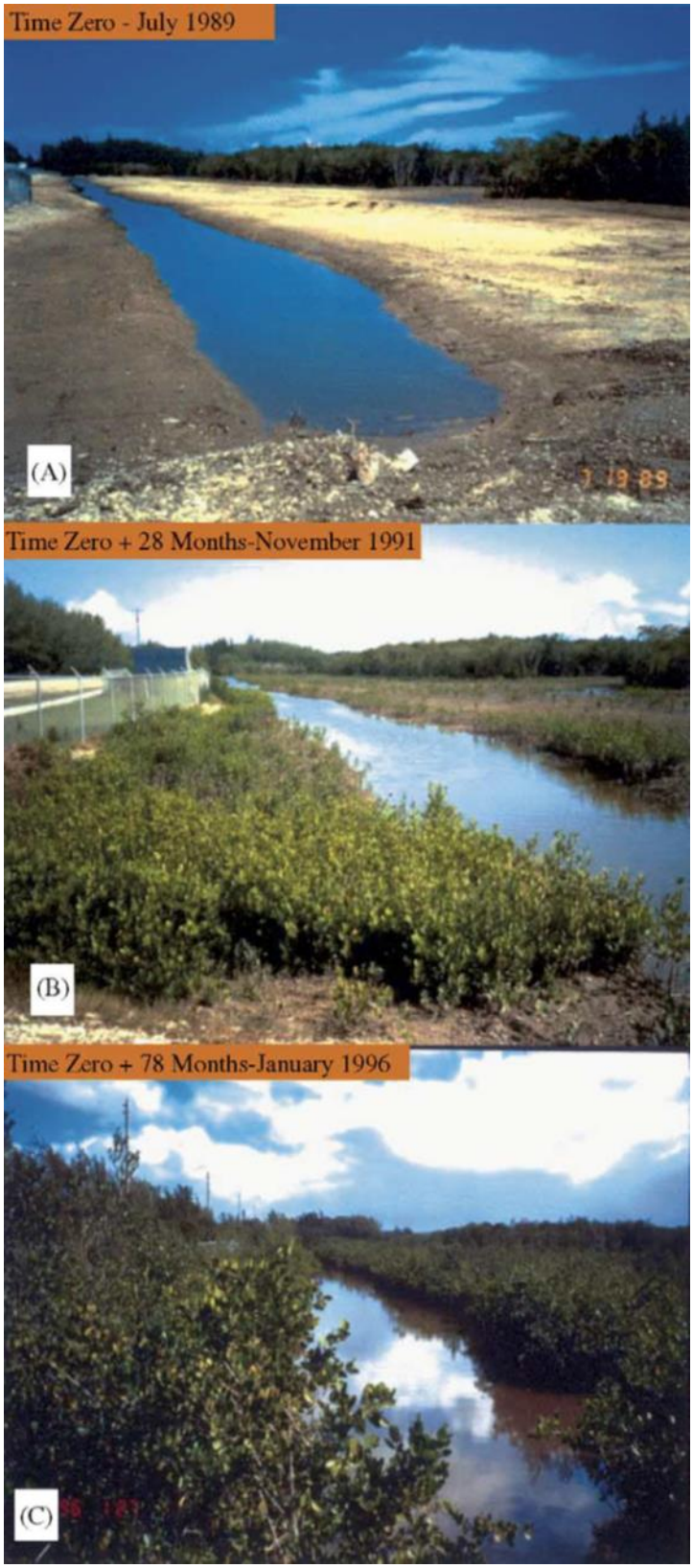


FIGURE 3-1 HYDROLOGIC MANGROVE RESTORATION PROJECT AT WEST LAKE PARK, HOLLYWOOD, FL, USA (A) JULY 1989 (B) NOVEMBER 1991 AND (C) JANUARY 1996. NO PLANTING OF MANGROVES OCCURRED

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

Brisbane Airport, Brisbane - Closer to home, similar focused attention to the topographic grade relative to adjacent natural mangroves in constructed mangrove wetlands was shown to be the key to success in a project at the Brisbane International Airport (Saenger, 1996). The rehabilitation process involved hydrologic restoration by channel digging and subsequent reforestation. Emeritus Professor Peter Saenger was contacted by email for further insights into this development and its success. Prof. Saenger provided references to his prior work at the Brisbane Airport and confirmed that most of the work involved 'moving' Serpentine Creek (See Figure 3-2, not to be confused with Serpentine Creek in proximity to the proposed MOA site) by excavating a new drainage line and stabilising it with mangroves (which was also the cheapest option at the time). Survival rates of the mangroves were monitored and reported from the time of initial planting (1981) until twelve years later (1993) which showed that the survival and growth rates of the plants were good and that within four to five years, natural recruitment was apparent. Consequently, a self-maintaining mangrove system had become established. He is also in support of improving the EMR protocols.

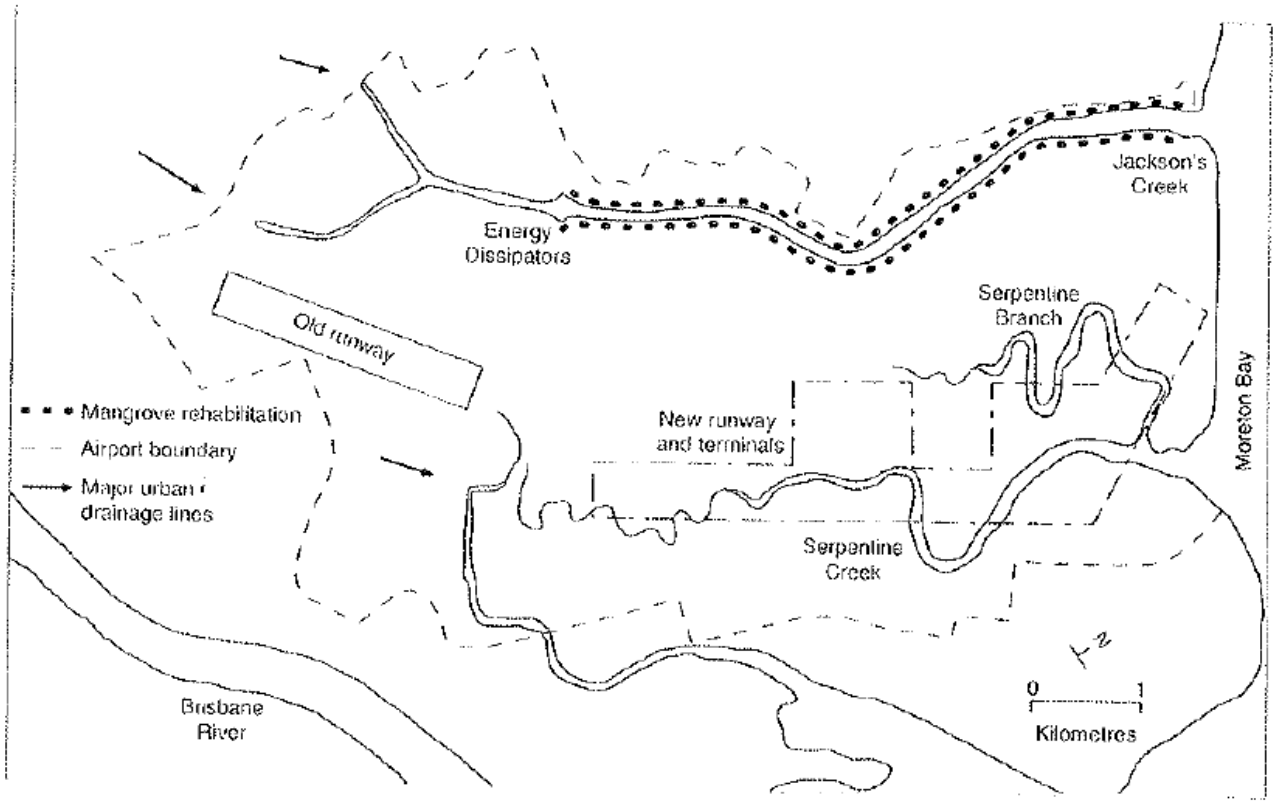


FIGURE 3-2 LOCALITY MAP SHOWING THE MANGROVE REHABILITATION AREA AND FORMER SERPENTINE CREEK IN THE AREA OF THE NEW BRISBANE AIRPORT (SOURCE: SAENGER, 1996)

Oxbow to Bulimba Creek, Brisbane - Another example of successful mangrove establishment in the Brisbane region is the innovative hydraulic rehabilitation undertaken to open up the Oxbow to Bulimba Creek and laser-controlled levelling of the site to enable significant recovery of extensive tidal wetlands including saltmarsh and mangroves (Figure 3-3). The Bulimba Creek Catchment Coordinating Committee's saltmarsh project is involved in ongoing restoration of Bulimba Creek that began in the year 2000 as an offset to the Port of Brisbane Motorway construction. This long-term project has been studied extensively and has been recognised with at least eight awards (Knight, 2018).

Queensland saltmarsh projects - Restoration of saltmarsh wetlands has occurred at several sites in Queensland including the following:

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

- Removal of aquaculture ponds (former Sun Sun prawn farm) and acid sulphate soil remediation in a 50 ha area adjacent to the Ross River in Townsville - restoring surface elevation and substrate suitable for saltmarsh colonisation (GHD, 2008).
- Removal of tidal bunds and ponded pastures to reinstate tidal inundation at Mungalla Station, Palm Creek (funded and delivered by the Department of the Environment, Mungalla and CSIRO) and Orient Creek, south of Ingham.
- Transplanting saltmarsh vegetation associated with the Houghton Highway duplication (frc environmental, 2010).

East Coast, Florida - Rey et al. (2012) described the success of this 'hydrologic restoration' approach (Lewis et al., 1985; Brockmeyer et al., 1997; Turner and Lewis, 1997) when implemented in 12,605 ha out of an original 16,185 ha mangrove area that was diked and filled on the East Coast of Florida, USA. The localities were hydrologically reconnected, breached, or restored for the rehabilitation of formerly diked mosquito control impoundments. Note that nursery establishment and planting of mangroves was only used under this protocol if natural propagule (mangrove seedling) recruitment did not occur after site preparation and monitoring. We note that planting of mangroves is not precluded under the EMR but is triggered only after a documented lack of natural establishment of propagules.

Southern States, India - The states of Tamil Nadu and Andhra Pradesh in India constructed artificial channels through excavations (1 m deep, 1.5 m wide at the base and 3 m wide at the soil surface) and connections to natural adjacent channels (Figure 3-4). Feeder channels (0.75 m deep, 0.6 wide at the base, and 1.5 m wide at the soil surface) were also excavated throughout the die-back mangrove area, following a "fish bone" spatial pattern (Figure 3-4). The excavated sediments were deposited next to the channels, increasing soil relative elevation. This strategy was designed to re-establish water exchange between the mangrove die-back areas and the natural channels with the goal of increasing the survival rate of planted and naturally established seedlings. The technique (i.e., feeder channels) was first tested around 1996 in a pilot study involving 10 ha of dead mangrove wetland and resulted in the recovery of an extensive mangrove forest area (Figure 3-4). After it was demonstrated to be successful, it was used in other areas covering at least 1,200 ha of impacted mangrove sites in the region (Selvam et al., 2005, López-Portillo et al., 2017).



FIGURE 3-3 BULIMBA-OXBOW MANGROVE REHABILITATION PROJECT PROGRESS - AERIALS OF THE SITE IN 2010 (TOP) AND 2017 (BOTTOM)



FIGURE 3-4 HYDROLOGICAL RESTORATION IMPLEMENTED IN TAMIL NADU, INDIA, SHOWING ORIGINAL MAIN AND FEEDER CHANNELS EXCAVATED CIRCA 1996. SITE IN MARCH 2003 (ABOVE) AND SITE IN JANUARY 2016 (BELOW) (SOURCE: GOOGLE EARTH)

3.1.2 Mangroves in WWTP Effluent Receiving Environments – Case Study

Mount St John, Townsville - The Mount St John Sewage Treatment Plant treats 16 ML of effluent per day, servicing approximately 106,000 EP. Sewage is treated by several processes which remove solids, organic matter and nutrients from the sewage so that it can be safely reused. The treated WWTP (referred to as STP for this case only) effluent is disposed of in three locations:

- Rowes Bay Golf Course irrigation;
- On site where it is re-used as service water; and
- Remained effluent is discharged to Snaggy Creek, which then flows into the Bohle River.

The treated effluent discharge via an outfall to Snaggy Creek is of special interest to this project in support of the due diligence assessments being undertaken. Snaggy Creek is a tributary of the Bohle River which discharges into Halifax Bay near Bushland Beach, before emptying into the Coral Sea. The catchment area of the river occupies 368 square kilometres of which an area of 26 square kilometres is composed of estuarine (mangrove) wetlands (Figure 3-5).

The Receiving Environment Monitoring Program (REMP) being implemented pertaining to the receiving waters of Snaggy Creek addresses the water quality targets to be achieved within the receiving environment, and the identification of specific contaminant concentrations or levels established to indicate adverse environmental impacts (if any). The REMP includes a Mid-Field Monitoring Program (MFMP) and a Far-Field Monitoring Program (FFMP) to monitor the effects of the release of contaminants from the Mount St John STP on the receiving environment, with the aim of identifying and describing the extent of any adverse impacts to local environmental values. The receiving environments covered by the programs are as follows:

- MFMP: Waters of Snaggy Creek downstream of the Mt St John discharge channel and the connected wetlands within the TCC Reserve (before the confluence of the creek system with the Bohle River)
- FFMP: Waters of the lower Bohle River estuary, upstream and downstream of the confluence with Snaggy Creek, and marine waters in proximity to the Bohle.

The contaminant release limits at the location of the Mt St John STP outfall to the discharge channel to Snaggy Creek are 5 mg/L TN and 1 mg/L TP (long-term 50th percentile). Townsville City Council supplied Water Technology with monthly/sub-monthly REMP data (from June 2014 to December 2018) for 5 (five) monitored sites within the receiving environments of the STP discharge. The sampling sites for the REMP monitoring are shown in Figure 3-5. The nutrient concentrations downstream of the STP outfall are presented in Figure 3-6 and Figure 3-7. The decrease in concentration of nutrients between the STP outfall and the monitoring station in closest proximity (LOU 1, located immediately after the connected wetland area) is significant. Further downstream (LOU 2 and BOH, located well into the mangrove coverage area), the measured TN and TP concentrations were also noticeably lower.

We note that the effluent uptake capacity of the Mount St John mangroves cannot be assessed in direct relation to the development being proposed (mangrove wetlands offset area) in this report for the following reasons:

- Daily discharge rates from the St John STP are significantly (approximately six times) higher than the proposed SRBWWTP;
- Due to higher recycled water discharge rates from the Mount St John STP, nutrient loads are also expected to be higher; and
- Pollutant concentrations and especially the presence of potentially more ‘exotic’ contaminants in the proposed SRBWWTP recycled water discharge will far lower than the Mount St John STP discharge, which services a catchment that includes hospitals and industries, and which also has a lower standard of treatment.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

Regardless of the above, this brief assessment of the Mount St John STP effluent discharge into the receiving environment dominated by mangroves indicates the significant potential for the implementation of a similar conceptual design to treat the recycled water discharge from the proposed SRBWWTP. It is highly likely that some of these improvements in water quality are due to tidal dilution as well as mangrove assimilation, however almost certainly the aforementioned improvements in water quality between the discharge and site LOU1 are due to mangrove uptake.

Other documented mangrove regeneration projects are listed in Appendix A.

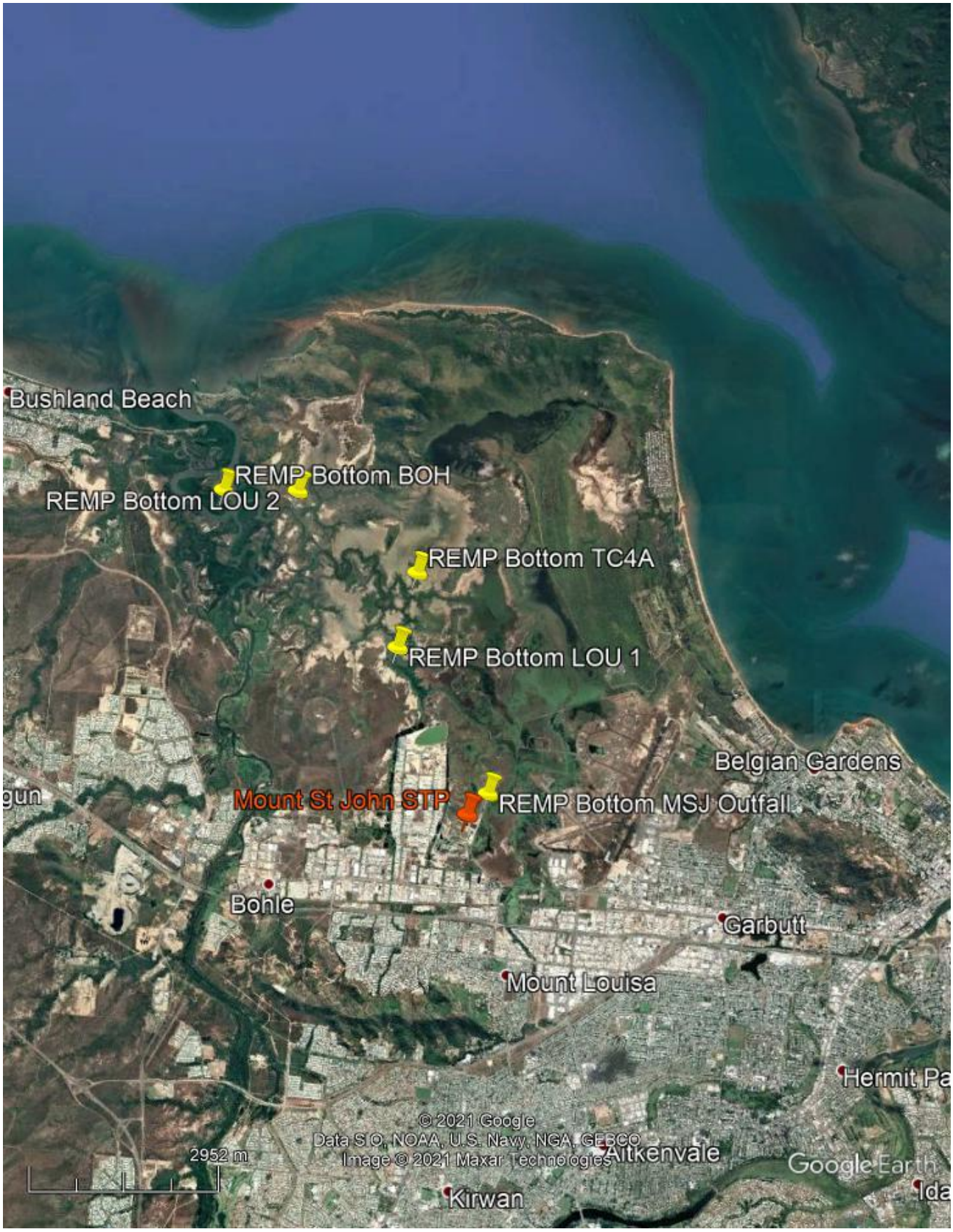


FIGURE 3-5 MOUNT ST JOHN REMP SITES

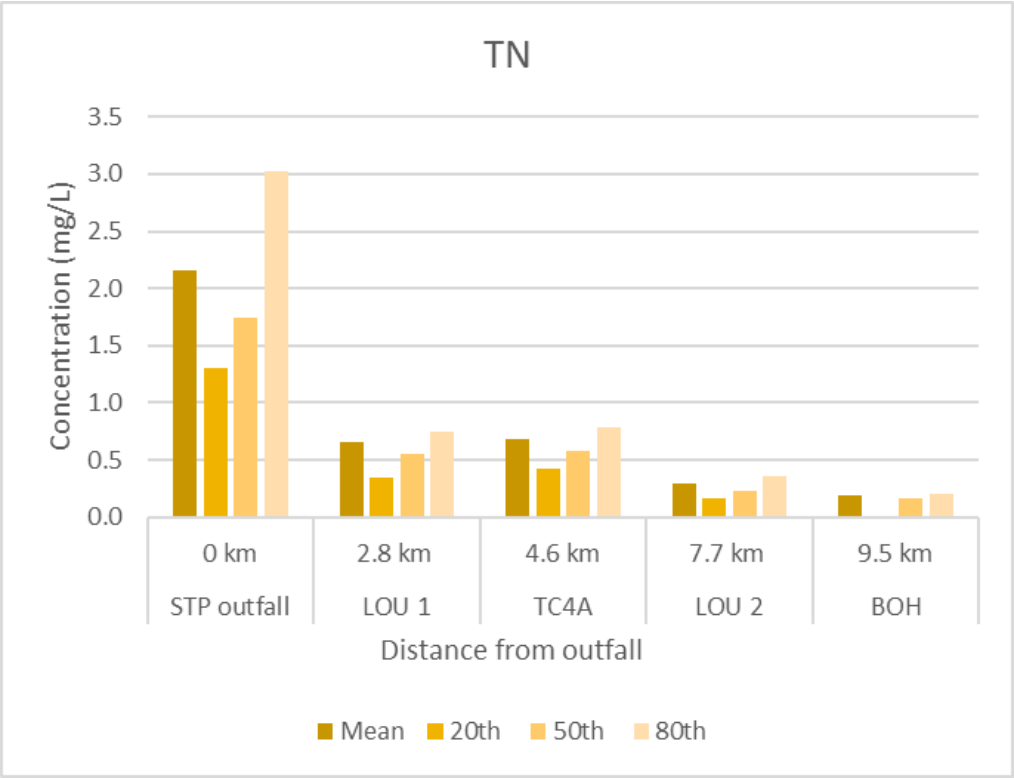


FIGURE 3-6 TN CONCENTRATIONS IN THE RECEIVING ENVIRONMENT OF MOUNT ST JOHN STP

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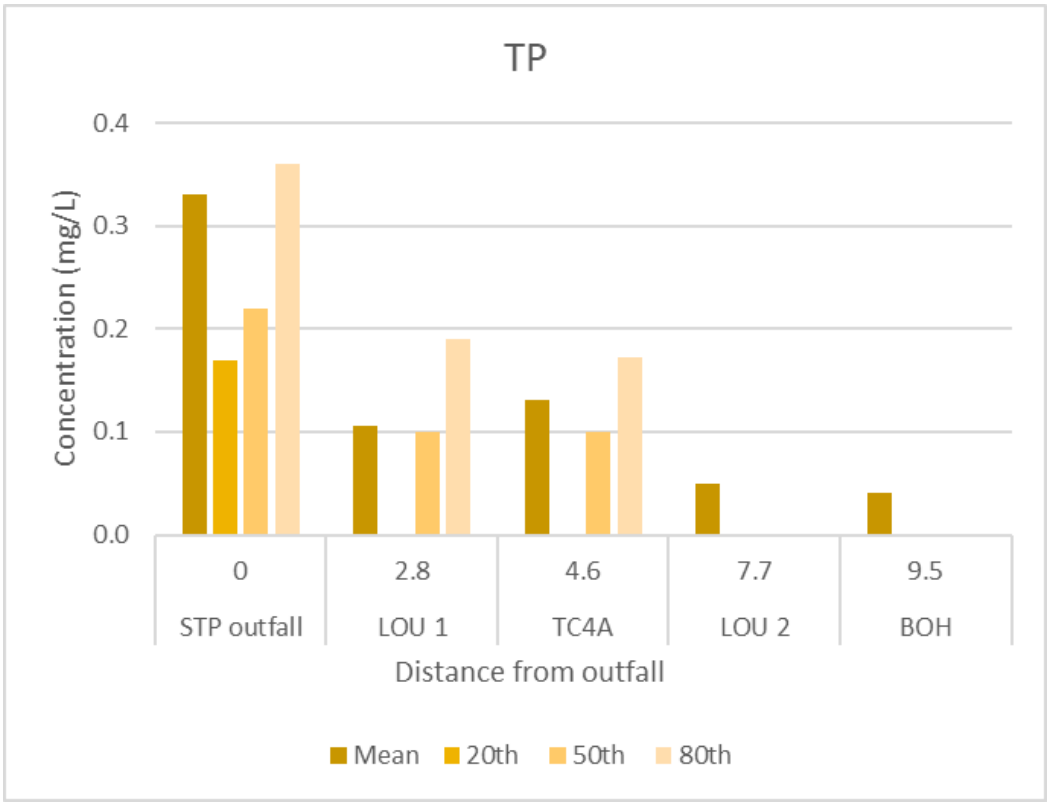


FIGURE 3-7 TP CONCENTRAITONS IN THE RECEIVING ENVIRONMENT OF MOUTN ST JOHN STP

3.2 The Southern Redland Bay WWTP Recycled Water Strategy

As outlined in the "Southern Redland Bay Wastewater Treatment Plant – Recycled Water Strategy (Stantec)", the proposed Southern Redland Bay WWTP is designed to produce recycled water with total nitrogen and phosphorus levels of 3 and 1 mg/L, respectively. The recycled water is expected to be of high quality and will be equal to or better than that required under Queensland and Australian Recycled Water Guidelines. A summary of the expected recycled water quality is provided in Table 3-1.

TABLE 3-1 SUMMARY OF RECYCLED WATER QUALITY

Parameter	Units	Value
Total Nitrogen	mg/L	3
Total Phosphorus	mg/L	1
Suspended Solids	mg/L	23
Total Dissolved Solids	mg/L	850
BODs (50th percentile)	mg/L	15
Turbidity	NTU	2
E.coli	cfu/100ml	<1
pH	-	6.5 - 8.5

Based on the expected wastewater generation and the requirement to allow up to 5 years for mangrove establishment prior to receival of recycled water, there will be zero discharge to the mangroves up until Year 4, when a minor discharge could occur during the wettest conditions (See Table 3-2). Average discharge

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

reaches around 19% by the end of Year 6 (assuming temporary irrigation continues), after which the (*by then established*) mangrove system will receive an increased portion of the recycled water. At ultimate development, approximately 0.3 ML/day of recycled water is proposed to be reused on average - with the remaining 2.4 ML/day discharged to the mangrove system (see Table 3-2).

As per the Recycled Water Strategy, the following staged approach to the management of recycled water will be implemented for the Southern Redland Bay WWTP:

- Phase 1: Tankering and Construction
  - Year 1 – Mangrove Offset Area (MOA) constructed and planting occurs to assist establishment. Wastewater from SRBWWTP's initial 200 lots is transported via mobile tankers to the existing RCC owned wastewater treatment facility at Victoria Point.
- Phase 2: No Discharge to Mangrove Wetland
  - Year 2 – Wastewater tankering ceases and Stage 1A of the Southern Redland Bay WWTP produces recycled water which is used to supply water for construction, landscaping and irrigation at local nurseries. There is no excess recycled water and therefore no discharge is required to the MOA.
- Phase 3: Increasing Discharge to Mangrove System
  - Years 3 and 4 – The recycled water storage (FSL) is established. Additional treated wastewater is used to supply the temporary irrigation of Lot 83 pasture. A small discharge volume is proposed to commence through the FSL to the MOA in Year 4.
  - Years 5 and 6 – Additional temporary irrigation for pasture in Lot 256 may be established with increasing discharge through the FSL and MOA. It is noted that by the end of years 5 or 6, depending on the success of MOA establishment, temporary irrigation may be ceased. Stage 1B of the Southern Redland Bay WWTP will be delivered around this time.
- Phase 4: Ultimate Scheme
  - Year 7 onwards – The temporary irrigation of Lots 83 and 256 is ceased. Excess recycled water will then be discharged to the established MOA. Recycled water used for sporting ovals and parks in the development area.
- After Year 25 - Following completion of the development (approximately year 25), on-going recycled water use will be of the order of 0.3 ML/day with the remainder being discharged to the MOA.

Critical to the wastewater disposal staging is to allow the effective establishment of the MOA before receiving significant discharges from the WWTP. The MOA is expected to take between 2 and 5 years to establish. It is not until Phase 3 (Year 4) that a small amount of treated wastewater is expected to be discharged to the MOA (Table 3-2). It is only at Year 6 that significant flows through the MOA are expected in all weather conditions.

TABLE 3-2 AVERAGE ANNUAL WASTEWATER VOLUME UNDER ADOPTED STRATEGY (YEARS 1 TO 6)

Year (Phase)	Estimated Average Daily Recycled Water Volume Discharged to MOA (ML/day)	Estimated Average Annual Recycled Water Volume Discharged to MOA (ML/year)
1 (1)	-	-
2 (2)	-	-
3 (3)	-	-
4 (3)	0.004	1.4

Year (Phase)	Estimated Average Daily Recycled Water Volume Discharged to MOA (ML/day)	Estimated Average Annual Recycled Water Volume Discharged to MOA (ML/year)
5 (3)	0.02	7.9
6 (3)	0.13	45.8
7 (4)	0.18	66.9
>25 years (Ultimate)	2.4	868.2

See Southern Redland Bay Wastewater Treatment Plant – Recycled Water Strategy (Stantec) for further details.

3.3 Nutrient Removal Rates and Offsets

In preparing the detailed conceptual design, discussions with experts helped identify key items to consider regarding nutrient removal in the proposed system prior to the commencement of due diligence assessments. These included the need for restoration of the original hydrology of the creek system surrounding the site and appropriate design of the channel for the recycled water discharge from the WWTP to the mangroves to ensure maximum travel time by possibly 'meandering' it through the mangroves. Establishing a salt marsh habitat surrounding the mangrove region was also recommended to assist in denitrification/nitrogen retention.

Wetland ecology expert Dr. Fernanda Adame from the Australian Rivers Institute, Griffith University was consulted for advice regarding nutrient removal/sequestration processes associated with the proposed wetland and estimating denitrification levels. Dr. Adame identified no issues with the ability of the proposed mangrove wetland in processing nitrogen, with denitrification as the main mechanism. Dr. Adame provided Water Technology with a methodology for measuring denitrification. Dr Adame also suggested that a combination of using both freshwater and mangrove wetlands was optimal for high nutrient removal efficiency.

Dr Alistair Grinham from the University of Queensland was also contacted for discussions concerning the proposed mangrove establishment and its potential in establishing a carbon offsetting scheme. Dr. Grinham was very supportive of the proposed scheme as a method for offsets and expressed his excitement at the (possible) opportunity to work on a project of this nature. It was suggested that various offsets could be calculated for the site (carbon dioxide, nitrous-oxide and methane being the most significant ones).

Based on the expert recommendations above, estimates were made of the nutrient removal rates from the mangroves and salt marshes prior to subsequent due diligence assessments. The nutrient removal rates were used to determine the sizing of the MOA with a sizeable factor of safety (See Section 3.3.3). For the conceptual and the eventual preliminary design of the MOA, offset options in the context of the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 were considered (See Section 3.3.1)

3.3.1 Offset Options

Under the Environmental Offsets Act 2014, an environmental offset is defined as an activity undertaken to counterbalance a significant residual impact of a prescribed activity on a prescribed environmental matter. In regard to the Act, we note that:

- An offset is not required to be a part of the treatment system;
- Can be located elsewhere within the catchment; and
- The coverage offset area is not a critical factor to the design, but the quantity of the offset achievable is.

'An environmental offset compensates for unavoidable impacts on significant environmental matters, (e.g. valuable species and ecosystems) on one site, by securing land at another site, and managing that land over

a period of time, to replace those significant environmental matters which were lost' – Queensland Government.

Based on the offset options in the context of the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 and as outlined in the Point Source Water Quality Offsets Policy 2019, the proposed MOA classifies as an "Other Best Practice and Innovative Approach" (see Figure 3-8). In support of this classification, we note that the proposed offset option is a novel and sustainable approach to managing a wastewater discharge to a receiving environment and is guided by the Queensland Wetlands Program[2]. The Queensland Wetlands Program recommends several practical rehabilitation techniques which are applicable to the proposed project, including the following:

- Hydrology restoration;
- Habitat restoration;
- Weed management;
- Native vegetation restoration;
- Soil erosion and acidity prevention; and
- Improving water quality;

According to the Queensland Wetland Program, there are two (2) pieces of Australian (Commonwealth) Government legislation and eight (8) important pieces of Queensland legislation that apply to activities and works that may be involved in rehabilitating wetlands. These are:

- Environmental Protection and Biodiversity Conservation (EPBC) Act 1999;
- Great Barrier Reef Marine Park Act 1975;
- Nature Conservation Act 1992;
- Environmental Protection Act 1994;
- Fisheries Act 1994;
- Coastal Management and Protection Act 1995;
- Integrated Planning Act 1997;
- Vegetation Management Act 1999;
- Water Act 2000;
- Land Protection (Pest & Stock Route Management) Act 2001;

The above legislations were considered and incorporated (as required) into the planning and design of the proposed MOA. The various legislations associated with this project are presented under separate titles as a part of the EA and EPBC submissions to DES.

The proposed plan was developed based on scientific research with strong evidence-based investigative assessments which are documented in this report. The investigations documented in this report demonstrate that the proposed land-based discharge of recycled water to the MOA can proceed with no adverse water quality impacts on the receiving environment.

Due to the novel nature of this proposed project, it is recommended that the offset option being proposed include a robust Factor of Safety (FOS) for the uptake of limiting nutrients (especially TN) in the system. The MOA was designed based on a minimum FOS of 2 (See Section 3.3.3). This exceeds the environmental

[2] Wetland Rehabilitation Guidelines for the Great Barrier Reef catchment, Australian Government.

equivalence ratio specified in the Point Source Water Quality Offsets Policy 2019[3], which recommends that the prescribed offset option's ability to meet net nutrient reductions is in accordance with the delivery ratio of 1.5.

In addition to offsets, we note that the proposed Mangrove Offset Area will:

- Provide valuable habitat for estuarine flora and fauna species;
- Provide nutrient and organic sequestration within the Mangrove Offset Area;
- Reduce carbon emissions through (a) removal of current CO_2 discharges from currently waterlogged soils on the site and subsequent in situ sequestration of carbon within the new mangrove forest and (b) avoiding the need for recycled water to be pumped long distances to an otherwise potentially suitable discharge location in Southern Moreton Bay;
- Provide a location of mangroves to 'retreat' in the event of predicted sea level rise, an attribute identified by researchers as being of limited capacity of the Moreton Bay region; and
- Provide additional flood storage to the lower Logan River system.

It is expected that this innovative and sustainable solution encompassing advanced wastewater treatment, recycled water reuse and environmental offsetting actions will be exemplar for future solutions of this nature in South East Queensland.

[3] Although the proposed MOA does not fall under the Point Source Water Quality Offsets Policy 2019, and with the "Other Best Practise and Innovative Approach" option not having a defined target for offsets, this comparison (with the Point Source Water Quality Offsets Policy 2019) allows for the proposed development to have a guiding target for a nutrient offset.

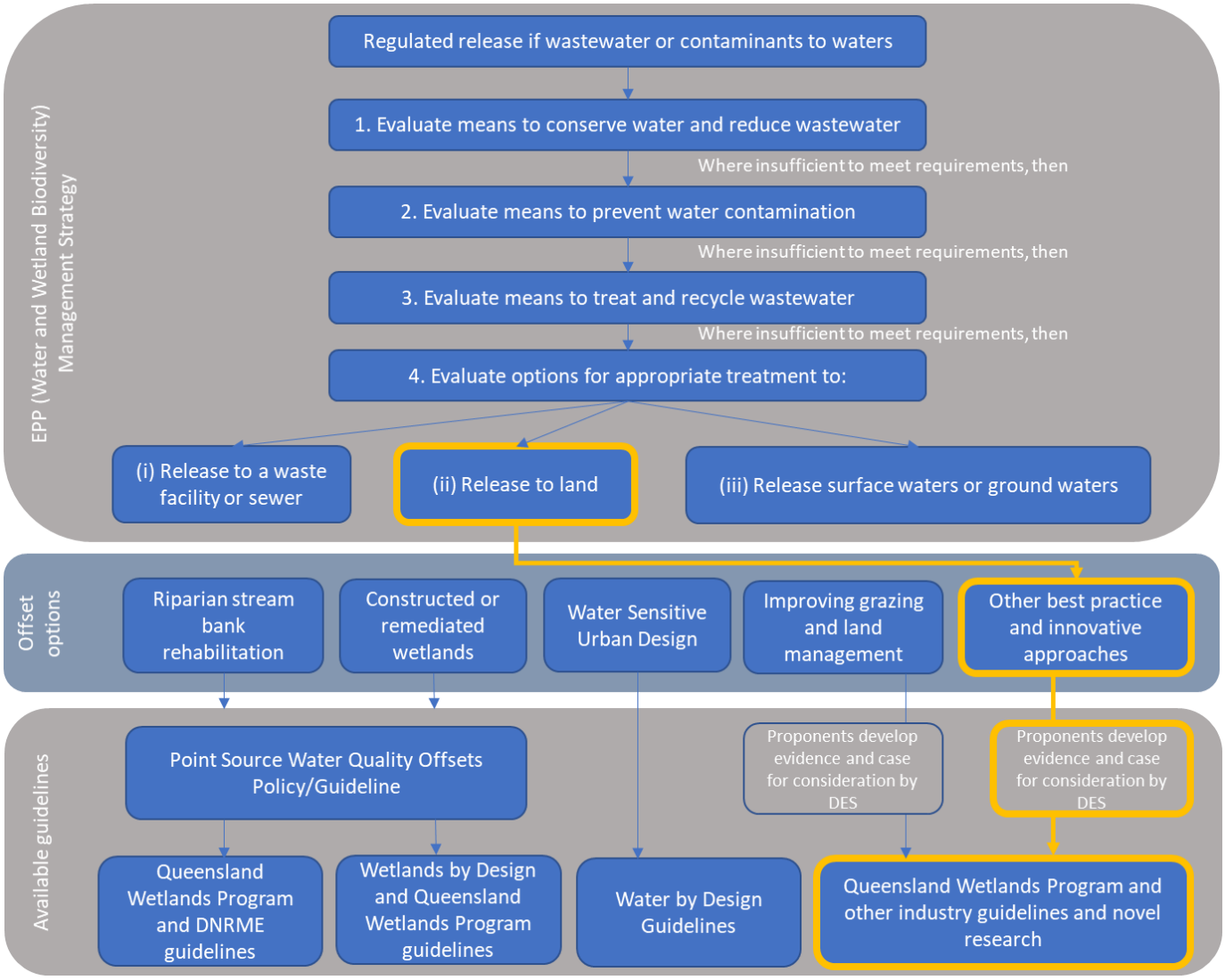


FIGURE 3-8 OFFSET OPTIONS BASED ON THE ENVIRONMENTAL PROTECTION (WATER AND WETLAND BIODIVERSITY) POLICY 2019[4].

3.3.2 Discharge from the Wastewater Treatment Plant

The due diligence assessments in Stage 1 and Stage 2 proposed that treated recycled water will be discharged into the MOA with the intent of offsetting the nutrient load from the Southern Redland Bay WWTP and avoiding the alternative of an outfall into Southern Moreton Bay.

The SRBWWTP development is expected to reach a population of 13,500 EP after 30 years. As initially proposed by the due diligence assessments in Stage 1 and Stage 2, the progressive increase in flows from the WWTP is expected to provide the MOA sufficient time to establish. In the early stages of the development, all treated recycled water will be directed, via a pumped discharge pipeline, to local open spaces including sports grounds and golf courses for land disposal. It is expected that as plant flows increase, a portion of recycled water will eventually be directed to discharge into the mangroves. This situation will not arise until some 4-5 years after the project commences. That is, the mangrove and saltmarsh areas will have a

[4] Management hierarchy table adopted from the Point Source Water Quality Offsets Policy 2019

considerable time period to establish and thereafter the rate of recycled water discharge will gradually increase in subsequent years.

Based on the latest Southern Redland Bay Wastewater Treatment Plant – Recycling Water Strategy (Stantec) for Stage 3, construction of the plant will be split into four (4) phases, with each stage providing progressively increased capacity for additional residents in line with population growth. Critical to disposal staging is to allow effective establishment of the MOA before receiving large volumes of recycled water discharge from the WWTP. The MOA is expected to take between 2 and 5 years to establish. It is not until Phase 3 (Year 4) that a small amount of recycled water will be discharged to the MOA (see Section 3.2 and Table 3-2). It is only after Year 6 that significant flows through the MOA are expected in all weather conditions.

Based on advise from Stantec, the estimated sewage flow and loads associated with the recycled water discharge quality/quantity at the proposed WWTP's full operational capacity are as follows:

Population contributing to the WWTP flow: 13,500 EP (2.7 EP/dwelling)

Per capita sewage flow: 200 L/EP/day

Average recycled water reuse: 0.3 ML/day

Average recycled water discharge quantity: 2.4 ML/day

Recycled water discharge quality: 3 mg/L TN, 1 mg/L TP

The estimated average daily flows and the corresponding effluent nutrient loads at the outlet of the WWTP for a 30-year planning period are presented in Table 3-3.

TABLE 3-3 ESTIMATED POPULATION AND AVERAGE DAILY FLOWS AND NUTRIENT LOADS

Year	Estimated Persons (EP)	Average Daily Recycled Water Discharge Quantity (ML/day)	TN Load (kg/day)	TP Load (kg/day)	TSS (kg/day)
2021	889	0.2	0.5	0.2	0.9
2026	3848	0.8	2.3	0.8	3.8
2028	5411	1.1	3.2	1.1	5.4
2031	8059	1.6	4.8	1.6	8.1
2036	12136	2.4	7.3	2.4	12.1
2050	13500	2.7[5]	8.1	2.7	13.5

3.3.3 Mangrove and Salt Marsh Nutrient Offset

A review of literature on the reported rates of sequestration of carbon in mangroves showed values in mangroves and salt marshes to be 163 g C m^{-2} $year^{-1}$ (Lovelock et al., 2014) and 54 g C m^{-2} $year^{-1}$ (Macreadie et al., 2017), respectively. Using the Redfield ratio (C:N:P = 106:16:1) in association with these values for C

[5] Excluding recycled water reuse (0.3 ML/day) at full operational capacity (See Section 3.2)

sequestration, equivalent capture rates of nitrogen and phosphorus were estimated. The estimated nutrient offsets that can be expected from mangrove and salt marsh habitats are shown in Table 3-4.

TABLE 3-4 NUTRIENT REMOVAL RATES IN MANGROVES AND SALT MARSHES

Nutrient	Mangroves	Salt marsh
Carbon Sequestration (tC/ha/y)	1.63	0.54
TN Offset (kg/ha/day)	0.8	0.265
TP Offset (kg/ha/day)	0.075	0.025

As well as uptake by sequestration in the mangrove plants themselves, further nitrogen will be taken up in algal mats that will establish on sediments within the MOA, which will subsequently be lost via denitrification when these algae die. Advice from Dr Fernanda Adame is that such removal rates are of the order of 4 mg/m^2/hr, or 1 kg/ha/day. When combined with the 0.8 kg/ha/day (Table 3-4), a total nitrogen loss rate of 1.8 kg/ha/day results. For salt marsh, nitrogen loss rate of 0.265 kg/ha/day is expected (Table 3-4).

The expected nitrogen uptake in the mangroves for the planning years (summarised in Table 3-3) are presented in Table 3-5. For a total nitrogen loss rate of 1.8 kg/ha/day, a minimum mangrove area of 4.5 ha is required to offset the expected ultimate nitrogen load from the SRBWWTP. As such, given that 8.7 ha of mangroves will actually be established, an inherent FOS of just under 2 is provided with this design. Should 0.3 ML/day of recycled water be allocated for reuse, the FOS increases to just under 2.2 with a minimum area requirement of 4 ha. Note that the salt marsh habitat that will establish around the MOA will also provide additional nutrient uptake (approximately 0.3 kg/day for a 1.1 ha establishment area). This is considered reasonable given the new and innovative nature of this design, inherent uncertainties around some of the data used in developing the sizing of the system and to provide a precautionary approach to ensure that the receiving environment is protected.

TABLE 3-5 AREA REQUIRED FOR THE MANGROVES AND ESTIMATED NUTRIENT UPTAKE

Time period (years)	Factor of Safety (FOS)	Area required to maintain FOS (ha)	Estimated TN uptake in proposed design area of 8.7 ha (kg/year)	Estimated TP uptake in proposed design area of 8.7 ha (kg/year)
2021 - 2026	n/a[6]	n/a	16 kg/day or 5716 kg/year	0.7 kg/day or 238 kg/year
2026 - 2028	6.8	1.3		
2028 - 2031	4.8	1.8		
2031 - 2036	3.2	2.7		
2036 - 2050	2.2	4.0		
2050 and beyond	1.9	4.5		

[6] Mangroves establishment is not expected until Year 2026. According to the 'Southern Redland Bay Wastewater Treatment Plant – Recycled Water Strategy (Stantec)', it is not until Phase 3 (Year 4, corresponds to year 2024) that a small amount of treated wastewater is expected to be discharged to the MOA (Table 3-3). It is only at Year 6 (approximately Year 2026) that significant flows through the MOA are expected in all weather conditions.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

3.3.4 Sewage Bypass

The MOA will receive intermittent wet weather bypass flows from the STP under heavy rainfall conditions (approximately 5 times per year) from Phase 3 (Year 5) onwards - when the mangroves will have become established. At such times, recycled water quality from the WWTP will degrade, however given the short duration of these events and passage through the mangrove system, no adverse water quality impacts on the Logan River are expected. Dilution, nutrient processing and assimilation within the estuarine system will also contribute to no adverse impacts in these areas.

Any risk of pathogens entering the MOA via wet weather bypass flows will be minimal due to the proposed disinfection of such flows, either via event based UV or chlorination and de-chlorination.

3.4 The Ecological Mangrove Rehabilitation/Restoration (EMR) Protocol

In preparing the detailed conceptual design and the targeted due diligence assessments to follow, emphasis was placed on planning and designing the MOA based on the six steps of Ecological Mangrove Rehabilitation/Restoration (EMR) protocol, to ensure that the procedures and methodologies adopted were technically sound and tailored to the needs of this project. The EMR protocol and relevant actions taken (through due diligence assessments) by Water Technology are listed below:

1. **Understand the autecology (individual species ecology) of the mangrove species at the site, the patterns of reproduction, propagule distribution, and successful seedling establishment.**

- Water Technology engaged the services of frc environmental to assist in producing a detailed report addressing all the above. This work was incorporated within a separate Ecological Assessment Report by SHG.
- In addition to the above, Water Technology sought guidance from field experts who have significant demonstrated expertise in this area, including Mr. Mik Petter and Mr. Stefan Hattingh from the Bulimba Creek Catchment Coordinating Committee (B4C). Advice from B4C was incorporated into the Ecological Assessment Report by SHG.

2. **Understand the normal hydrologic patterns that control the distribution and successful establishment and growth of targeted mangrove species.**

- Water Technology undertook hydraulic modelling to estimate the elevation levels required to maintain suitable hydrologic patterns within the MOA in relation to the Logan estuary and its natural tidal patterns. The modelling also supported culvert sizing works for the tidal inlet and outlet of the MOA (See Hydrodynamic Modelling for Culvert Sizing report by Water Technology).
- Water Technology undertook water quality assessments to understand nutrient behaviour (from the recycled water discharge from the WWTP) of the proposed MOA. Salinity levels within the mangroves and sediment inflow patterns into the MOA were assessed in the due diligence process to ensure necessary design considerations were considered.

3. **Assess the modifications of the previous mangrove environment that currently prevent natural secondary succession.**

- For this proposed project, rehabilitation involves habitat-creation. The environment of the proposed MOA site was found to be at an elevation that required a certain amount of modification for natural mangrove propagation/establishment. This was validated through due diligence assessments described in steps 1 and 2 above. Effective mangrove environments can be effectively achieved with the correct elevations with hydrological viability in mind, which have been thoroughly accounted for by the due diligence processes.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

- Geotechnical assessments were performed by Douglas Partners to identify and assess all factors that may affect the stability and suitability of the proposed excavation. This included testing for acid sulphate soils.
- The development was assessed for any existing risks associated with flooding and erosion in the area. Preliminary assessments of coastal processes were made by Water Technology in Stage 2, followed by detailed assessments as per SPP 2017 (See Appendix K).
- In addition to the above, the following assessments were made to include and address any other concerns associated with the progress of the proposed development.
  - Viruses and microorganisms – in Stage 1 and 2, Water Technology engaged CSIRO to perform a site-specific virus (both enteric viruses and the White Spot Syndrome Virus) risk assessment. Additional pathogen tracer assessments were undertaken in Stage 3 (See Section 9.1.4).
  - Potential impacts on local Flora and Fauna were assessed by SHG in Stage 2 to determine impacts (if any) on the surrounding flora and fauna habitats. This was further improved and incorporated in detail in the Ecological Impact Assessment by SHG.

4. **Select appropriate mangrove restoration sites through application of Steps 1–3. These steps increase the likelihood of success in restoring a sustainable mangrove forest ecosystem and are cost-effective given the available funds and manpower to implement projects, including adequate monitoring to assess quantitative goals established prior to restoration. This step includes resolving landowner - ship/use issues necessary for ensuring long-term access to and conservation of the site.**

- Fortunately, the proposed project site is known to be in proximity to existing mangrove environments. Figure 3-9 shows the natural mangrove propagation along Serpentine Creek, the northern bank of the Logan River and to the east of the site over the past decade. Issues such as ensuring long-term access to and conservation of the site will be dealt with at a later stage by Lendlease.

5. **Design the restoration program at appropriate sites selected in Step 4 to initially restore the appropriate hydrology and utilize natural mangrove propagule recruitment for plant establishment.**

- Fortunately, in this instance, assessments showed that lowering bed elevations will assist with the natural establishment of mangroves. However, planting of propagules is advised to speed up this process. This has been addressed further in the Concept Rehabilitation Plan by SHG.

6. **Only utilize actual planting of propagules, collected seedlings, or cultivated seedlings after determining through steps 1–5 that natural recruitment will not provide the quantity of successfully established seedlings, rate of stabilization, or rate of growth of saplings established as quantitative goals for the restoration project.**

- This has been addressed in detail in the Concept Rehabilitation Plan by SHG.

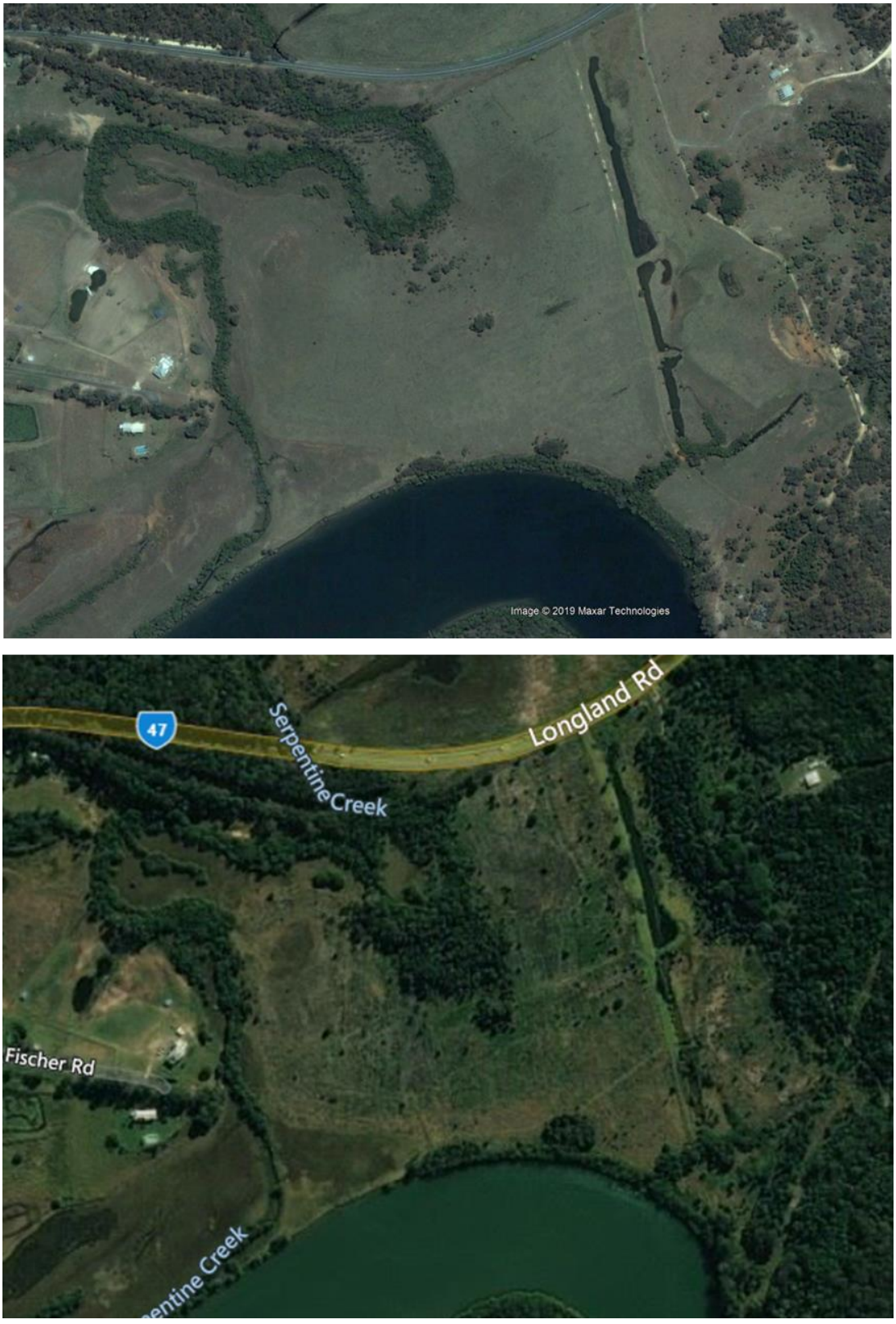


FIGURE 3-9 PROPOSED SITE FOR MANGROVE ESTABLISHMENT CIRCA 2004 (TOP) AND 2019 (BOTTOM) SHOWING NATURAL MANGROVE PROPAGATION (SOURCE: GOOGLE MAPS)

3.5 Stage 2 Assessments

Throughout the conceptual design phase (Stage 1), advice and guidance was sought from professionals and academics in the field to develop a thorough understanding of the processes involved in nutrient removal and sequestration that will occur in the proposed FSL and MOA. Upon developing the conceptual plan, which included the preferred layout and configuration (Figure 3-10) of the FSL and MOA systems, comprehensive, well-informed and targeted due diligence assessments were carried out based on the EMR protocol (Section 3.4).

The conceptual design of the FSL and MOA system included the following components:

Freshwater Storage Lagoon – A modified freshwater storage pond.

Mangrove Offset Area – Designed to occupy most of the site area in the west with a central mangrove area and salt marsh located on the outer fringes of the proposed mangrove habitat.

Tidal Inlet – Located on the eastern side of the site, closer to the mouth of the Logan River, designed for unidirectional inflow controlled by the 'east gate'.

Tidal Outlet – Located on the western side of site, further from the mouth of the Logan River, designed for unidirectional outflow controlled by the 'west gate'.

Recycled Water Discharge – Located to the north-east of the site, in proximity to the freshwater storage lagoon.

Deeper Central Flow Channel – Designed to meander through the MOA to provide maximum recycled water engagement with mangroves and salt marsh areas within the site.

Sediment Pit – Designed to trap suspended sediments from tidal inflows.

Stage 2 advanced the due diligence assessments identified in Stage 1 by addressing the following:

- Mangrove establishment;
- Water quality studies and impacts;
- Health and safety impact of pathogens in wastewater discharge;
- Constructability through hydrological assessments and costing;
- Environmental Impact of the land-based discharge into the mangroves and residual impacts to the Logan River, coastal impacts, impacts on flora and fauna and fisheries; and
- Geotechnical review/impacts including acid sulphate soil management.

Findings from the due diligence assessments were adapted into Stage 3 assessments (this report), wherein analyses were revised and updated as the design of the system was iteratively refined.

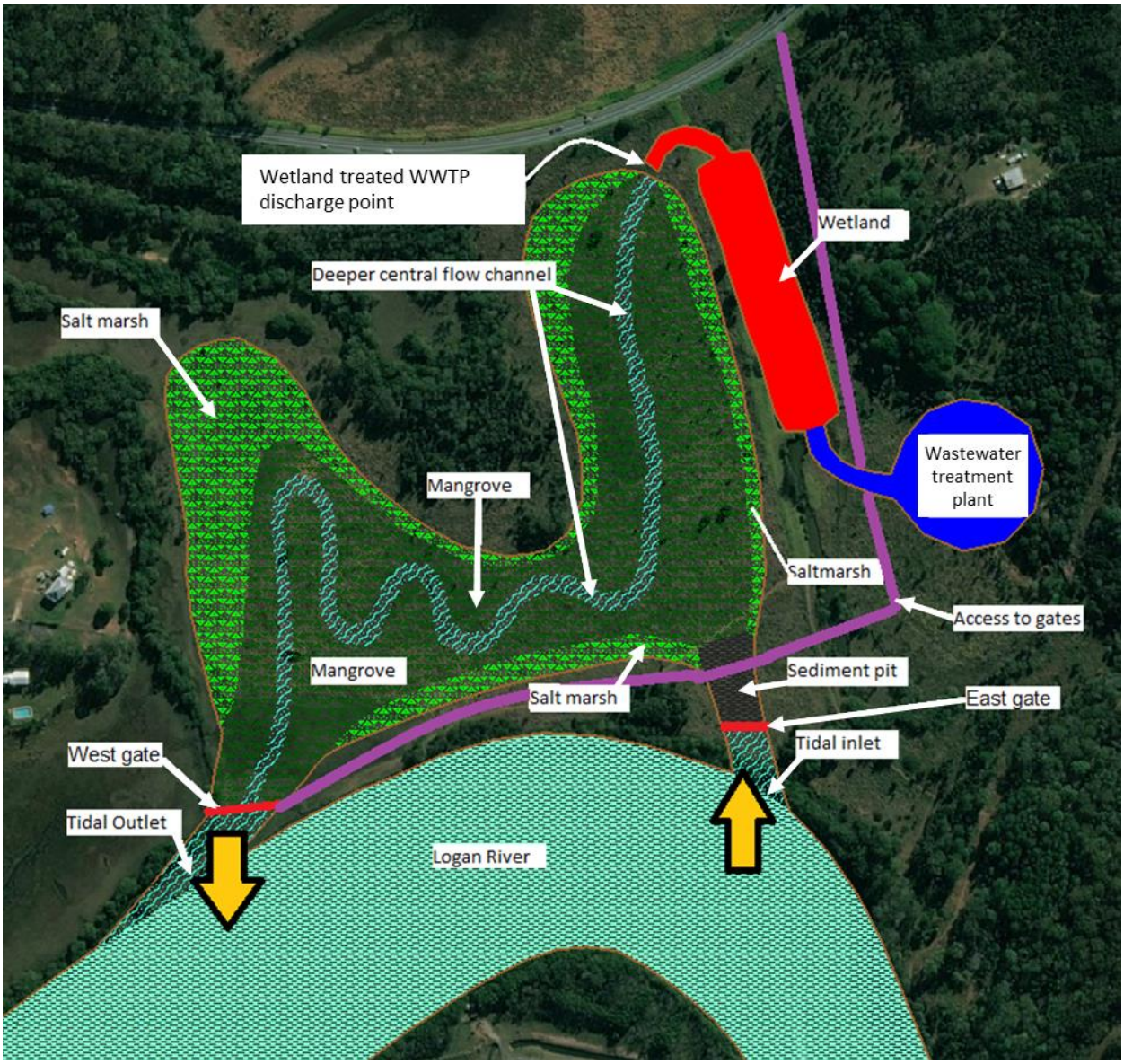


FIGURE 3-10 SRBWWTP MANGROVE CONCEPTUAL DESIGN PLAN (NOTE: THIS FIGURE IS ILLUSTRATIVE ONLY)

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

4 ENVIRONMENTAL VALUES AND WATER QUALITY OBJECTIVES

Environmental Values (EVs) are the qualities of water that make it suitable for supporting aquatic ecosystems and human water uses. These EVs need to be protected from the effects of habitat alteration, wastewater releases, contaminated runoff and changed flows to ensure healthy aquatic ecosystems and waterways that are safe for community use.

Water quality guidelines defined in the Environmental Protection (Water) Policy (EPP (Water) 2009) are numerical concentration levels or statements for indicators that protect a stated environmental value. Under the EV setting process contained in the EPP (Water), water quality guidelines are used as an input to the development of **Water Quality Objectives (WQOs).**

'Water quality indicator' is a property that is able to be measured or decided in a quantitative way. Examples of water quality indicators include physical indicators (e.g. temperature), chemical indicators (e.g. nitrogen, phosphorus, metals) and biological indicators (e.g. macroinvertebrates, seagrass, fish).

Water quality objectives (WQOs) means the WQOs specified to support the EVs for waters identified, which in this case is the Logan Estuary. WQOs are long term water quality management goals. They are numerical concentration levels or narrative statements of indicators established for receiving waters to support and protect designated EVs for those waters.

The EVs and WQOs for the SRBWWTP are governed by the EPP (Water) 2009 and apply to fresh, estuarine and marine surface waters and groundwaters draining the Logan River catchment, as indicated in the accompanying plan (WQ1454) (Figure 4-2 and Figure 4-3). Plan WQ1454 shows that the site can be mapped in the following zones:

- Marine/Estuarine Waters (Middle Estuary);
- Freshwaters (Lowland); and
- Rivers and Creeks.

The EVs applicable to the site are summarised in Figure 4-1.

The SRBWWTP site is located 5.5 km upstream of the mouth of the Logan River Estuary. The site has no frontage to High Ecological Value (HEV) sites in Southern Redland Bay (Figure 4-3). Changes to hydrology and water quality due to the proposed SRBWWTP have the potential to affect the ecological and water quality characteristics of:

- The Logan River Estuary; and
- Immediate waterways including the estuarine reaches of Serpentine Creek, which is adjacent to the Site.

Relevant site-specific WQOs that are applicable to the site are summarised in Table 4-1.

It is important to note that WQOs governed by the EPP 2009 are not site-specific objectives, rather they are generic scheduled objectives for the region within Part of Basin 145. These WQOs are intended to represent average water quality in the entire zone covered by Plan WQ1454. In the context of this development, given the unique nature of the WWTP and the MOA design, a methodology for assessing the impact of treated recycled water on the receiving waterways using standardised WQOs is not easily defined. However, site-specific objectives can be generated for the site based on ANZECC water quality guidelines in the presence of a robust water quality management plan.

	Coastal Sub-Catchment	
Environmental Values	**Logan River – enclosed coastal and estuary**	**Serpentine Creek**
Aquatic ecosystems	●	●
Seagrass	●	
Irrigation		
Farm Supply/use		
Stock water		●
Aquaculture	●	
Human consumer	●	●
Oystering	●	
Primary recreation	●	
Secondary recreation	●	●
Visual recreation	●	●
Drinking water		
Industrial use		
Cultural and spiritual values	●	●

FIGURE 4-1 ENVIRONMENTAL VALUES (EVS) FOR LOGAN RIVER CATCHMENTS RELATING TO THE SITE (SOURCE : EPP (WATER) 2009)

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

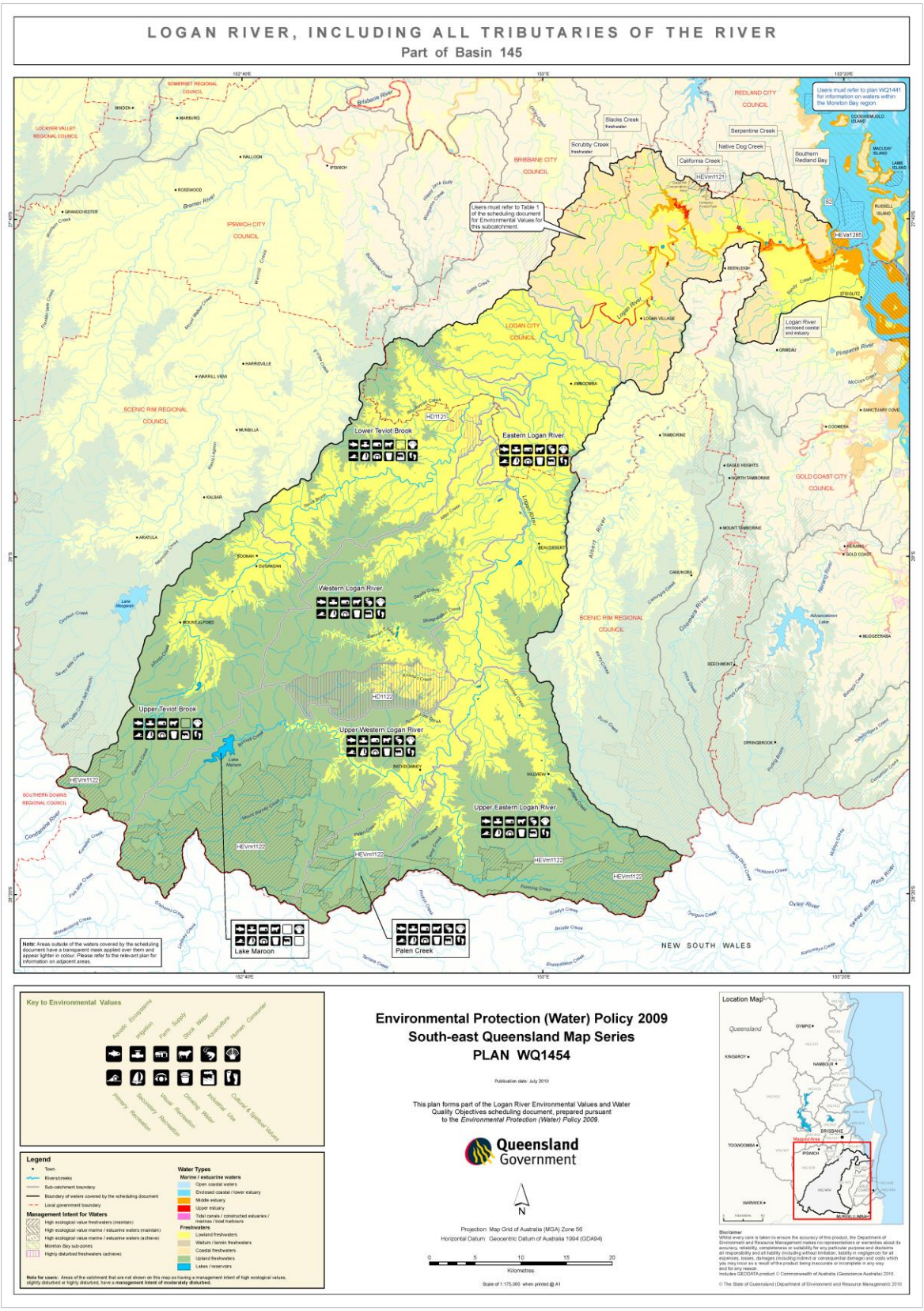


FIGURE 4-2 ENVIRONMENTAL PROTECTION (WATER) POLICY 2009 – LOGAN RIVER AND TRIBUTARIES

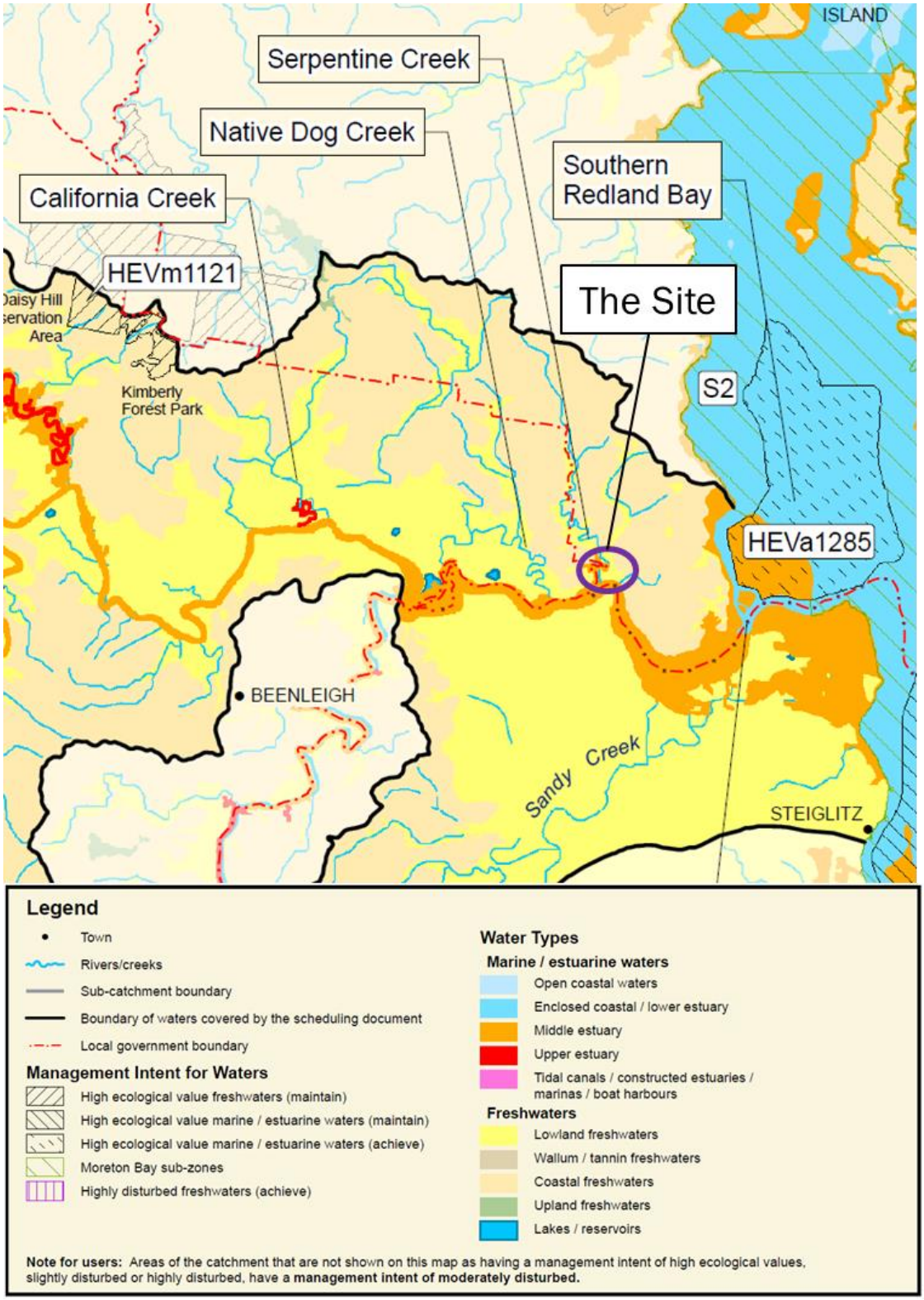


FIGURE 4-3 ENVIRONMENTAL PROTECTION (WATER) POLICY 2009 (EXTRACT) – THE SITE

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

TABLE 4-1 SITE-SPECIFIC WATER QUALITY OBJECTIVES TO PROTECT AQUATIC ECOSYSTEMS (SOURCE: EPP (WATER) 2009)

Water area/ type	Management intent (protection level)	WQO to protect aquatic ecosystem EVs
Marine and Estuarine Waters		
Mid estuary	Aquatic ecosystem – moderately disturbed	■ turbidity: <8 NTU ■ suspended solids: <20 mg/L ■ chlorophyll a: <4 µg/L ■ total nitrogen: <300 µg/L ■ oxidised N: <10 µg/L ■ ammonia N: <10 µg/L ■ organic N: <280 µg/L ■ total phosphorus: <25 µg/L ■ filterable reactive phosphorus (FRP): <6 µg/L ■ dissolved oxygen: 85 – 105% saturation (20th—>80th percentile) ■ pH: 7.0 – 8.4 ■ secchi depth: >1.0m (20th percentile) Note: For waters shown on the plan as being mid estuary (orange colour) and occurring within inter-tidal zones of Moreton Bay, these waters may have water quality characteristics more in common with adjacent water areas/types (Southern Bay—S2). Under such circumstances, reference should be made to WQOs for the S2 water area shown above.
Area S2 – Southern Bay/lower estuary	Aquatic ecosystem – moderately disturbed	■ turbidity: <7 NTU ■ chlorophyll a: <2.0 µg/L ■ total nitrogen: <200 µg/L ■ oxidised N: <2 µg/L ■ ammonia N: <5 µg/L ■ organic N: <190 µg/L ■ total phosphorus: <24 µg/L ■ filterable reactive phosphorus (FRP): <8 µg/L ■ dissolved oxygen: 95 – 105% saturation (20th—>80th percentile) ■ pH: 8.1 – 8.4 ■ secchi depth: >1.2m (20th percentile) Note: minimum secchi depth needed to restore seagrass to areas where it has been lost is 1.7m Maintain the existing seagrass depth limit for Zostera muelleri of -1.3m AHD (50th percentile)
Freshwaters		
Lowland freshwater (comprising lowland streams, wallum/tannin stained streams and coastal streams)	Aquatic ecosystem – moderately disturbed	■ turbidity: <10 NTU ■ suspended solids: <6 mg/L ■ chlorophyll a: <5 µg/L ■ total nitrogen: <500 µg/L ■ oxidised N: <60 µg/L ■ ammonia N: <20 µg/L ■ organic N: <420 µg/L ■ total phosphorus: <50 µg/L ■ filterable reactive phosphorus (FRP): <20 µg/L ■ dissolved oxygen: (20th—>80th percentile) % saturation 85% – 110% ■ pH: 6.5 – 8.0 ■ conductivity: 780 µS/cm

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

Water area/ type	Management intent (protection level)	WQO to protect aquatic ecosystem EVs
For ALL freshwaters within this Table	All	For additional biological WQOs, see Table 3 of the original document. Toxicants in water and sediment as per AWQG (2000): ■ Toxicants in water: refer to AWQG section 3.4 - 'water quality guidelines for toxicants' (including Tables 3.4.1, 3.4.2, and Figure 3.4.1) ■ Toxicants in sediments: refer to AWQG section 3.5 - 'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1) Comply with Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance, ANZECC.

Another relevant guideline considered for this assessment is **Phase 2 of the Australian Guidelines for Water Recycling (AGWR): Augmentation of Drinking Water Supplies (EPHC, 2008)**. The AGWR provide a risk management framework, rather than simply relying on end-product (reclaimed-water) quality testing as the basis for managing water recycling schemes. They include concentration-based numeric guidelines for at least 86 pharmaceuticals in reclaimed water. The guideline concentrations are based on the application of a safety factor of 1,000 to 10,000 relative to a single therapeutic dose. These are not mandatory and have no formal legal status, but they were provided as nationally consistent guidance for recycling projects. In general, the guideline concentrations are far higher than concentrations found in drinking water or reclaimed water.

While there is no definitive risk assessment tool for some types of trace chemical constituents in recycled water, the Australian guidelines do provide a methodology for evaluating the potential risk from known and emerging chemical constituents (NHMRC- NRMMC, 2004; EPHC, 2008; and Snyder et al., 2010).

There are some differences between the drinking water and water recycling guidelines. We note that aspects included in the water recycling guidelines but not in the drinking water guidelines that are relevant to this assessment are:

- Health-based performance targets, including required reductions of microbial and chemical hazards; and
- Use of reference pathogens.

Phase 2 of the Australian Guidelines for Water Recycling (AGWR) includes a discussion of pharmaceuticals, personal-care products and compounds with potential endocrine disrupting activity to a greater extent than in the Australian Drinking Water Guidelines (NHMRC–NRMMC 2004) or Phase 1 of the water recycling guidelines. Where chemicals are not dealt with in the drinking water guidelines, AGWR provides an approach for determining guideline values.

Therefore, where applicable, trace chemical constituents and other such 'emerging' issues of potential concern will be assessed (see Section 7) against the following guidelines:

- Health Values based on the ADWG 2011;
- Queensland Public Health Regulation Standard 2018; and
- WQO for Aquatic EVs under EPP(Water).

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

5 THE STATE PLANNING POLICY

5.1 State Interest – Water Quality

The SPP contains state interest policies and where relevant, the assessment benchmarks for each state interest. All the following state interest policies must be appropriately integrated in planning and development outcomes, where relevant.

The State Planning Policy (SPP 2017) requires that the environmental values and quality of Queensland waters be protected and enhanced. Where relevant, the following state interest policies must be appropriately integrated in planning and development outcomes:

- Development facilitates the protection or enhancement of environmental values and the achievement of water quality objectives for Queensland waters.
- Land zones for urban purposes are located in areas that avoid or minimize the disturbance to:
  - High risk soils;
  - High ecological value aquatic ecosystems;
  - Groundwater dependent ecosystems; and
  - Natural drainage lines and landform features.
- Development is located, designed, constructed, and operated to avoid or minimize adverse impacts on environmental values of receiving waters arising from:
  - Altered stormwater quality and hydrology;
  - Wastewater (other than contaminated stormwater and sewage);
  - The creation or expansion of non-tidal artificial waterways; and
  - The release and mobilization of nutrients and sediments.
- At the construction phase, development achieves the applicable stormwater management design objectives in table A (Part G, Appendix 2) of SPP (2017).
- At the post-construction phase, development:
  - Achieves the applicable stormwater management design objectives on-site, as identified in table B (Part G, Appendix 2) of SPP (2017); or
  - Achieves an alternative locally appropriate solution off-site that achieves an equivalent or improved water quality outcome to the relevant stormwater management design objectives in table B (Part G, Appendix 2) of SPP (2017).
- Development in water resource catchments and water supply buffer areas avoids potential adverse impacts on surface waters and groundwaters to protect drinking water supply environmental values.

5.2 Assessment Benchmarks

The performance outcomes for the Southern Redland Bay WWTP development will need to be assessed for the following:

- For receiving waters, a development application for:
  - Operational works for an urban purpose that involves disturbing a land area 2,500 metres or greater in size.

- For the development, assessment benchmarks are as follows:
  - Development is located, designed, constructed and operated to avoid or minimise adverse impacts on environmental values arising from:
    - Altered stormwater quality and hydrology;
    - Wastewater; and
    - The release and mobilisation of nutrients and sediments.
- Development achieves the applicable stormwater management design objectives outlined in Tables A and B (Part G, Appendix 2) of SPP (2017).

Compliance with the State Planning Policy (2017) is addressed in Appendix L.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

6 MONITORING FOR BASELINE CONDITIONS, METHODOLOGY

The water quality assessments in this report are based on data collected by the following:

- Ecosystem Health Monitoring Program (EHMP) by Healthy Land and Water, which is used by Healthy Land and Water to quantify annual waterway health using state-of-the art receiving water quality models; and
- Water quality monitoring that was specifically implemented for this project to verify existing water quality in the Logan River in the vicinity of the Southern Redland Bay Wastewater Monitoring Project Site, and against available EHMP data and corresponding water quality guidelines.

6.1 Ecosystem Health Monitoring Program (EHMP)

Healthy Land and Water (HLW) coordinates the Ecosystem Health Monitoring Program (EHMP) to assess pressures facing South East Queensland (SEQ) waterways. Annual report cards are produced for estuarine and marine reporting zones which are assigned an Environmental Condition Grade (A-F) indicative of ecosystem health and are also assessed for the level of social and economic benefits (1-5 stars) the waterways provide to the community.

Using data collected for the EHMP (See Figure 6-1), HLW has overseen the development of state-of-the-art catchment pollutant models (Source) and three dimensional hydrodynamic and water quality models (TUFLOW-FV) that are used to calculate the HLW Report Card each year. The Source modelling framework is used to simulate how catchment land uses and climate variables such as rainfall affect sediment and nutrient generation in SEQ catchments. The outputs from HLW's Source models provide input data on pollutant loads for the Receiving Water Quality Models (RWQM) which are subsequently used to predict annual water quality medians for each estuarine and marine reporting zone.

6.2 Water Quality Monitoring

Additional water quality monitoring (in-situ readings and sampling) was undertaken to provide further data on baseline water quality in the immediate proximity of the SRBWWTP. The monitoring consisted of two (2) rounds of in-situ measurements and sample collection for a total of three (3) analysis sites (see Figure 6-2), which were located:

- Approximately 1 km upstream of the proposed discharge location (Upper Reach);
- Approximately 1 km downstream of the proposed discharge location (Lower Reach); and
- Adjacent of the proposed discharge location.

For each location, monitoring occurred as follows:

- One monitoring round at each location during high tide; and
- One monitoring round at each location during low tide.

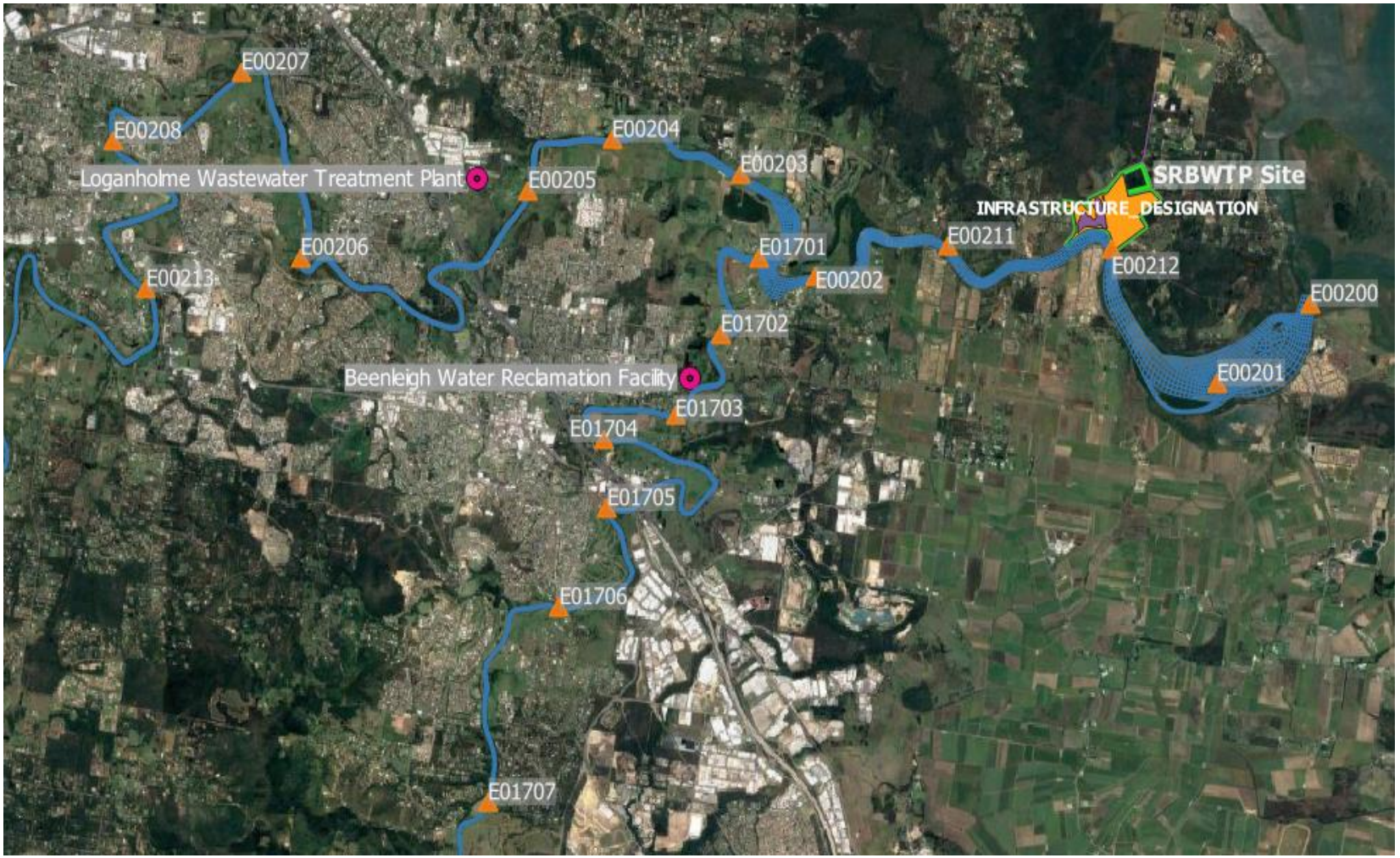


FIGURE 6-1 EHMP SITES IN THE LOGAN RIVER CATCHMENT (MARKED AS ORANGE TRIANGLES)

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

In-situ water quality readings were measured in the water column, 0.3 m below the water surface, for the following parameters:

- Temperature;
- Dissolved oxygen (DO);
- pH;
- Electrical conductivity;
- Turbidity; and
- Redox.

Water quality samples were also collected 0.3 m below the water surface for laboratory analysis for a comprehensive suite of microbiological and chemical parameters in line with the current scope of recycled water monitoring undertaken for the Western Corridor Recycled Water Project. The analysis included testing for the following parameters:

- E.coli;
- Thermotolerant Coliforms;
- Enterococci;
- Total Organic Carbon (TOC);
- Biological Oxygen Demand (BOD);
- Nutrients (Total Nitrogen and Total Phosphorus, including speciated nutrients); and
- Total and Dissolved Metals;

As well as the standard analysis suite above, samples were also tested for:

- Per- and Polyfluoroalkyl Substances (PFAS) and precursor Total Oxidisable Precursor Assay (TOPA);
- Benzene Toluene Ethylbenzene Xylenes and Naphthalene (BTEXN);
- Total Recoverable Hydrocarbons (TRH) (C6-C40);
- Polycyclic Aromatic Hydrocarbons (PAH);
- Endocrine Disrupting Compounds (EDC);
- Pharmaceuticals and Personal Care Products (PPCPs); and
- Herbicides and Pesticides and Polychlorinated biphenyls (PCBs).

The sites sampled were located in proximity to EHMP sites E00212 and E00211 (See Figure 6-2).



FIGURE 6-2 SRBWWTP WATER QUALITY MONITORING SITES IN RELATION TO EHMP SITES

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

6.3 Hydrodynamic Monitoring

Hydrodynamic monitoring was conducted in the vicinity of the inlet and outlet of the MOA along the Logan River in May 2020. The parameters measured are shown in Table 6-1 and described in detail in the following sub-sections. Monitoring was conducted to provide data against which the veracity of the receiving hydrodynamic model could be assessed, the results of which are discussed in Section 8.

TABLE 6-1 HYDRODYNAMIC MONITORING

Instrument	Parameter
Water logger	Temperature, water level
M9 ADCP (Acoustic Doppler Current Profiler)	Discharge, current speed direction, water depth

6.3.1 Discharge Transects

Water column current velocity and discharge data were measured at strategic locations using an M9 RiverSurveyor ADCP. The M9 ADCP is a nine-beam system with two sets of four profiling beams and one vertical beam. The multiple frequency approach is robust and allows continuous shallow-to-deep measurements. A deterministic microcontroller automatically apportions the appropriate acoustics, bin size and pulse schemes. The instrument specification for the M9 ADCP is shown in Table 6-2.

During deployment, the system was mounted on a flotation device (hydroboard) and towed at slow speed across predefined transects (Figure 6-3 and Figure 6-4).

TABLE 6-2 INSTRUMENT SPECIFICATION FOR THE M9 ADCP

Parameter Description	ADP
Transducer Configuration	Dual 4-beam 3,000 kHz and 1,000 kHz Vertical beam echosounder 500 kHz
Mounting	Download looking from hydroboard
Profiling Range (distance)	0.06 m to 40 m
Profiling Range (velocity)	+/- 20 m/s
Vertical Resolution (Bin Size)	0.02 to 0.5 m
Blanking Distance	0.4 m
Current Measurement Interval	10 minutes

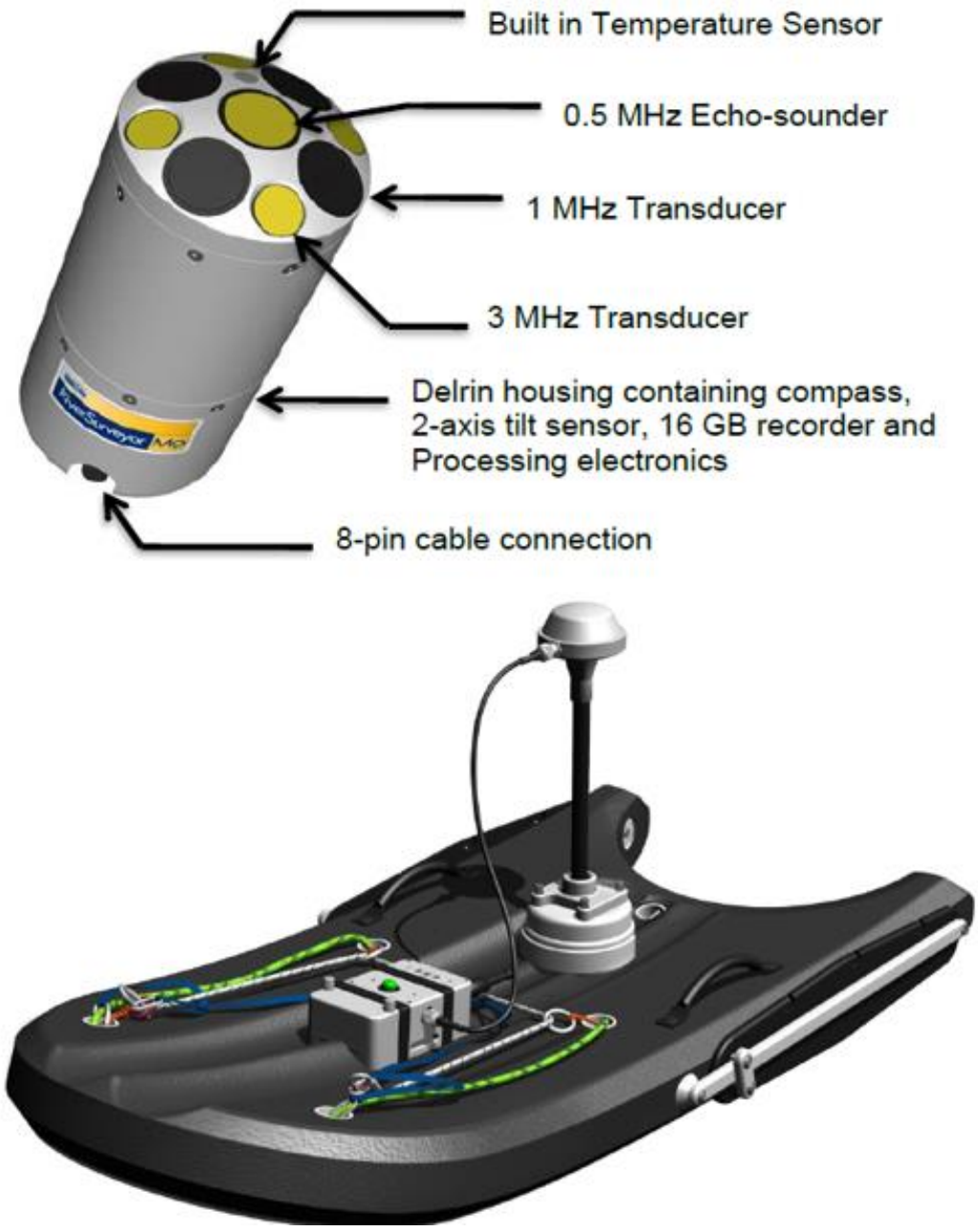


FIGURE 6-3 M9 UNIT (UPPER) AND M9 PLACED IN THE HYDROBOARD (SOURCE: SONTEK 2018)

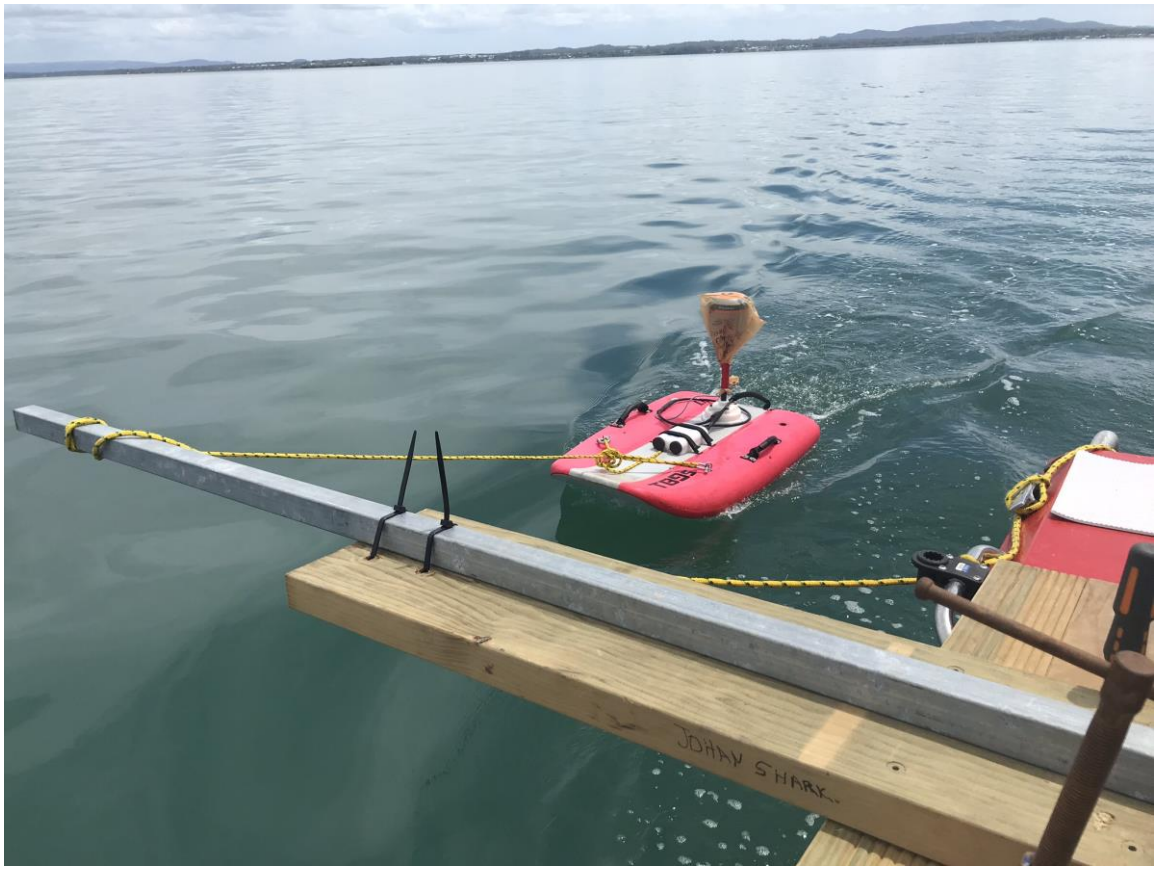


FIGURE 6-4 ADCP M9 UNIT DURING DATA COLLECTION (EXAMPLE)



FIGURE 6-5 SENSUS ULTRA DIVE LOGGING DEVICE

6.3.2 Water Level Loggers

Water elevation data was collected using Sensus Ultra dive logging devices. These devices are 3cm x 4cm (Figure 6-5) and are capable of recording depth and temperature data at a resolution of ~1.3cm and 0.01°C, respectively. For this study, four (4) instruments were deployed to capture tidal level and temperature data in the inlet and outlet areas of the proposed Mangrove Offset Area.

Prior to deployment, each instrument was securely mounted onto a Besser brick which was tethered to a surface float (Figure 6-6).



FIGURE 6-6 WATER LEVEL LOGGER MOUNTED ONTO BESSER BRICK

7 MONITORING FOR BASELINE CONDITIONS, RESULTS

This section summarises both available EHMP data and the outcomes of the bespoke sampling program outlined in Section 6.2. Measured water quality data for EHMP and the 6 bespoke monitored sites are presented in a summary table (Table 7-1). Local samples for this project were taken on the 20th of April 2020.

Water quality parameters tested were assessed against relevant region-specific guidelines. Additionally, recommended guideline values for physico-chemical parameters and toxicants, respectively, to be applied for saltwater (brackish and marine) aquaculture were assessed where relevant.

7.1 Physico-Chemical Parameters

As per the WQOs for moderately disturbed aquatic ecosystems in the Logan River (mid estuary) the water quality in the sampled locations were as follows :

- pH was generally within normal range of 7.0 to 8.4 and within guideline values.
- Conductivity:
  - High tide: Conductivity was higher, and as expected higher still towards the mouth of the Logan
  - Low tide: Conductivity was lower
- Dissolved oxygen: Ranged from 6.4 mg/L – 9.5 mg/L and was noticeably lower during high tides
- Turbidity was found to be within guideline values, and:
  - High tides: Values were lower, ranged from 5.1 NTU upstream to 3.1 NTU downstream
  - Low tides: Values were higher, ranged from 4.5 NTU upstream to 5.7 NTU downstream
- Total Nitrogen: Concentrations ranged between 0.5 mg/L - 0.8 mg/L, and generally higher during low tides. Considerably exceeding guideline values (See Section 9 for a detailed estuarine impact assessment).
- Total Phosphorus: Concentrations were generally higher during low tides. Values exceeded guideline values in all instances (See Section 9 for a detailed estuarine impact assessment).
- Pathogens: E.coli and thermotolerant coliforms Enterococci were in excess of recommended AWRG levels (See Section 9.3.3 for a detailed pathogen risk assessment).

In general, water quality was poor in terms of nutrient levels at all sample locations. Total Nitrogen and Total Phosphorus concentrations reduced towards the lower reaches of the Logan River Estuary, which is understandable due to tidal flushing.

TABLE 7-1 GENERAL WATER QUALITY

Parameter	Unit	Upper Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (High Tide)	Adjacent (Low Tide)	Lower Reach (High Tide)	Lower Reach (Low Tide)	EHMP (May 2019 – May 2020) 50th	EHMP (May 2019 – May 2020) 20th	EHMP (May 2019 – May 2020) 80th	WQOs for moderately disturbed aquatic ecosystems in the Logan River (mid estuary)
pH	-	7.89	8.01	7.96	8.03	7.97	8.05	7.9	7.9	8.0	7.0 – 8.4, 6.0-9.0*
Conductivity	uS/cm	43600	35200	45600	33700	47400	31200	48100	39200	54200	-
Dissolved Oxygen	mg/L	6.5	8.2	6.6	8.9	6.4	9.5	6.6	5.9	7.1	>5*
Temperature	° C	23.1	24	23.2	24.2	23.1	24.3	23.5	20.9	26.1	-
Turbidity	NTU	5.1	5.2	3.1	4.5	3.1	5.7	4.4	2.9	8.1	<8
Escherichia coli	cfu/100mL	<1	1	2	2	4	2	-	-	-	-
Thermotolerant Coliforms (MF)	cfu/100mL	<1	1	3	3	4	3	-	-	-	-
Enterococci	cfu/100mL	4	4	10	3	6	7	-	-	-	-
Ammonia N	mg/L	0.045	0.082	0.045	0.039	0.04	0.051	0.01	0.01	0.02	<0.01
Nitrite N	mg/L	0.003	0.01	0.002	0.006	<0.002	0.007	-	-	-	<100*
Nitrate N (Calc)	mg/L	0.026	0.11	0.023	0.04	0.02	0.045	-	-	-	<100 000*
Nitrite+Nitrate	mg/L	0.029	0.12	0.025	0.046	0.02	0.052	0.08	0.01	0.11	-
Total Kjeldahl Nitrogen	mg/L	0.69	0.66	0.57	0.75	0.49	0.73	-	-	-	-
Total Nitrogen	mg/L	0.72	0.78	0.6	0.8	0.51	0.78	0.3	0.2	0.5	<0.3
Ortho Phosphorus	mg/L	0.063	0.068	0.044	0.086	0.038	0.075	0.04 (as FRP)	0.04 (as FRP)	0.06 (as FRP)	<0.006
Total Phosphorus	mg/L	0.084	0.12	0.061	0.11	0.055	0.096	0.06	0.06	0.08	<0.025

*Relevant ANZECC 2018 guidelines for the protection of aquaculture species (cultured fish, molluscs and crustaceans) are derived from Table 4.4.3 in Chapter 4 (Primary Industries) in ANZECC 2000 guidelines.

7.2 Heavy Metals

According to ANZECC guidelines (2018), in the case of metals, the first option is to test the total (particulate plus dissolved) metals concentration against the guideline value. However, realistically, it is generally the dissolved fraction that is bioavailable rather than any particulate forms. Therefore, soluble metals can be reliably compared to the guideline value. Results for heavy metals and trace element concentrations for the sites sampled are presented in Appendix B, which presents both total and soluble values for trace elements against the following:

- Trigger values for marine water (µg/L) – For 95% species protection;
- Low reliability trigger values (derived from ANZECC 2018 guidelines; and
- Toxicant guidelines for the protection of aquaculture species (saltwater).

A summary of the findings of these assessments is provided below.

In essence, essentially all existing heavy metal concentrations were below guideline levels.

Aluminium – ANZECC 2018 has insufficient data to determine guideline trigger values for Aluminium. Total Aluminium was observed to be between 0.18 mg/L and 0.31 mg/L for the different samples tested. However, dissolved Aluminium was <0.2 mg/L for all samples. This can be expected to be below the low reliability trigger value (<0.1 mg/L) as per ANZECC 2018, which are indicators only and not guideline values.

Arsenic – Total and bioavailable values for Arsenic were well-below the prescribed guideline values for all samples.

Cadmium – Total and bioavailable values for Cadmium were well-below the prescribed guideline values for 95% species protection for all samples.

Chromium – Total and bioavailable values for Chromium were well-below the prescribed guideline values for 95% species protection for all samples.

Copper – Total and bioavailable values for Copper were <0.004 mg/L and are expected to be below the prescribed guideline values for 95% species protection (0.0013 mg/L).

Iron – ANZECC 2018 has insufficient data to determine guideline trigger values for Iron. Total Iron was observed to be between 0.23 mg/L and 0.4 mg/L for the different samples tested. However, dissolved Iron was <0.004 mg/L for all samples. This is below the low reliability trigger value (0.3 mg/L) as per ANZECC 2018, which are indicators only and not guideline values.

Lead – Total and bioavailable values for Lead were <0.004 mg/L for all samples, which is well below the prescribed guideline values for 95% species protection (0.0044 mg/L).

Manganese – ANZECC 2018 has insufficient data to determine guideline trigger values for Manganese. Total Manganese was observed to be between 0.016 mg/L and 0.03 mg/L for the different samples tested. However, dissolved Manganese was <0.004 mg/L for all samples. This is below the low reliability trigger value (<0.01 mg/L) as per ANZECC 2018, which are indicators only and not guideline values.

Mercury – Total and bioavailable values for Mercury were <0.1 mg/L for all samples, which is well below the prescribed guideline values for 95% species protection (0.4 mg/L).

Nickel – Total and bioavailable values for Nickel were <0.004 mg/L for all samples, which is well below the prescribed guideline values for 95% species protection (0.07 mg/L).

Zinc – Total for Zinc were between <0.004 mg/L and 0.0091 mg/L across the samples, which is well below the prescribed guideline values for 95% species protection (0.07 mg/L).

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

7.3 Pharmaceuticals and Personal Care Products (PPCPs)

To assess the levels of PPCPs in the waters of the Logan River Estuary, Queensland Public Health Regulation Standard Guidelines (2018) values were used. PPCPs concentrations for the sites sampled are presented in Appendix C.

Essentially, for all existing and tested PPCPs', concentrations in the Logan River Estuary were significantly below guideline levels.

Low concentrations for PPCPs were recorded **despite considerable effluent loads from upstream WWTPs** in the Logan River.

7.4 Endocrine Disrupting Compounds (EDC)

To assess the levels of EDCs in the waters of the Logan River Estuary, Queensland Public Health Regulation Standard Guidelines (2018) values were used. EDCs concentrations for the sites sampled are presented in Appendix D.

Essentially, for all existing and tested EDCs', concentrations in the Logan River Estuary were significantly below guideline levels.

Low concentrations for EDCs were recorded **despite considerable effluent loads from upstream WWTPs** in the Logan River.

7.5 Herbicides, Pesticides and Other Constituents

Results for concentrations of Herbicides, Pesticides and Others Compounds including Polychlorinated Biphenyls (PCBs) for the sites sampled are presented in Appendix E, Appendix F and Appendix G, respectively.

- Australian Drinking Water Guidelines (ADWG) Health Values were used to assess the levels of herbicides in the waters of the Logan River Estuary.
- Australian Drinking Water Guidelines (ADWG) Health Values were used to assess the levels of pesticides (including pyrethroids) in the waters of the Logan River Estuary.
- For Polychlorinated Biphenyls (PCBs) and Other Compounds, no recommended guidelines are prescribed.

The levels of herbicides and pesticides were considerably lower than guideline values. Although herbicides and pesticides are more likely to exist in the Logan River due to upstream catchment runoff, some levels of these compounds can be expected to be present in WWTP effluent. Additionally, we note that WWTPs upstream of the SRBWWTP site are older and are expected to have significantly lower treatment capabilities when compared to the proposed Southern Redland Bay MBR.

All tested Polychlorinated Biphenyls (PCBs) and 'Other' Compounds were found to be below their respective reporting limits.

8 NUMERICAL MODELLING OF THE LOGAN RIVER ESTUARY

8.1 Methodology

An existing numerical model of the Logan-Albert River system (the legacy model) was adopted and refined to predict potential impacts in the estuary attributable to the proposed development. The existing model was developed for the Healthy Land and Water (HLW) report card initiative and was successfully calibrated throughout the Logan River Estuary using EHMP data for 2018-2019.

The existing HLW model mesh was refined to better resolve the complex bathymetric features and flow patterns in the Logan-Albert River system. To assess the refined model's performance, model results have been compared to measurements collected during the data collection portion of the study. Figure 8-1 depicts the refined mesh (in blue) in Logan-Albert River and the locations (orange triangles) of the measurements used to demonstrate model's performance.

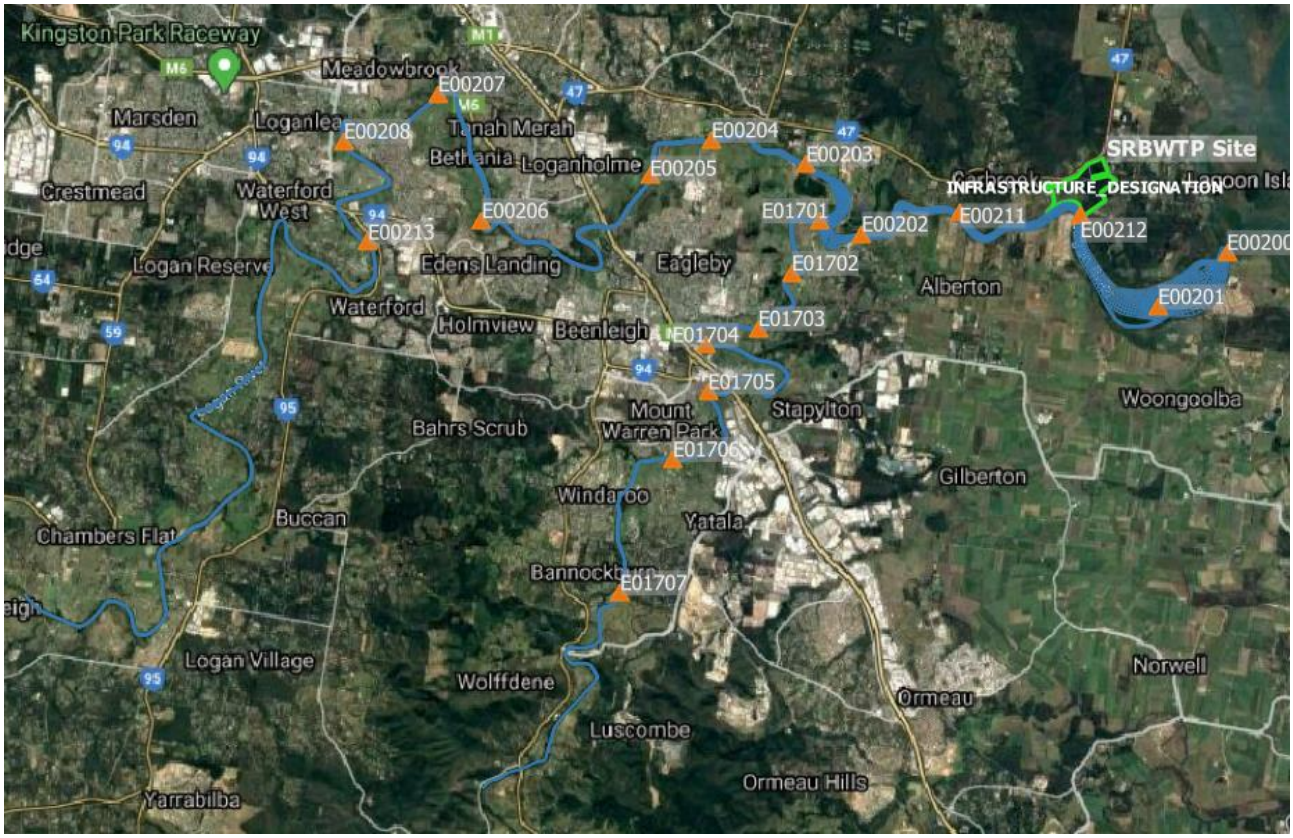


FIGURE 8-1 TUFLOW FV MODEL MESH FOR THE LOGAN RIVER

The numerical model was developed and simulated using the software package TUFLOW FV which can simulate hydrodynamic, sediment and water quality processes in three dimensions, with forcing from a comprehensive suite of boundary conditions (TUFLOW 2018). TUFLOW FV uses a flexible mesh, consisting of triangular and quadrilateral elements of different sizes and shape. Compared to a fixed grid approach, this has significant benefits for applications of complex geometry, or sharply varying flow and concentration gradients.

8.2 Boundary Conditions of the Legacy Model

8.2.1 Tides

The downstream boundary of the existing Logan-Albert TUFLOW-FV model was forced by water levels derived from tide monitoring.

8.2.2 Atmospheric

The atmospheric boundary was forced by wind, air temperature, relative humidity, shortwave radiation and longwave radiation. Wind data was sourced from several BOM weather stations and spatially interpolated over the model mesh, to create a spatially and temporally variable wind field.

The remaining atmospheric forcing was derived from the NCEP Climate Forecast System Version 2, which is a global weather model (Saha et al. 2011).

8.2.3 Wastewater Treatment Plants

Inflows of freshwater and nutrients into the Logan-Albert Estuary from the Loganholme and Beenleigh WWTPs were derived from measurements provided via the state Water Tracking and Electronic Reporting System (WaTERS).

8.2.4 Catchment Inflows

Inflows of freshwater, sediment and nutrients from the catchment were derived from a third-party numerical catchment model.

8.3 Hydrodynamic Model Calibration

8.3.1 Water Level Calibration

The bathymetry within the legacy model was largely inferred using outdated and incomplete measurements. Whilst the hydrodynamics were adequately represented in the lower and mid reaches of the Logan-Albert estuary, the misrepresentation of various local bathymetric features had a significant impact on simulated water levels in the upper reaches of the estuary. Figure 8-2 illustrates that the legacy model overpredicted the extent to which the low tide was able to propagate into the upper reaches of the Logan-Albert estuary.

In late 2019, the bathymetry of the Logan-Albert Estuary was surveyed. These latest measurements were incorporated into the model during this study. Numerous refinements to the model's mesh were also required to adequately resolve bathymetric features. Figure 8-2 illustrates that the improved model is far more capable of simulating water levels in the upper reaches of the estuary.

The volume of water which flows through a given cross section in an estuary is a function of the tidal range and surface area of the estuary upstream of the cross section. Thus, improvements in the model's capacity to simulate the water levels in the upper reaches improves the model's capacity to simulate tidal currents in the lower reaches. Furthermore, the extent to which water within the estuary is vertically mixed is largely dependent on the vertical density gradients, current speeds and bathymetric features. Thus, by carefully representing the bathymetric features in the lower reaches of the estuary, further improvements regarding the simulation of the complex dependencies between vertical density gradients and vertical mixing can be realised.

Figure 8-4 presents a comparison between the measured ADCP tidal flow data in the Logan estuary and the predictions made by the TUFLOW FV model. This shows that the model is doing an excellent job of reproducing tidal flows.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

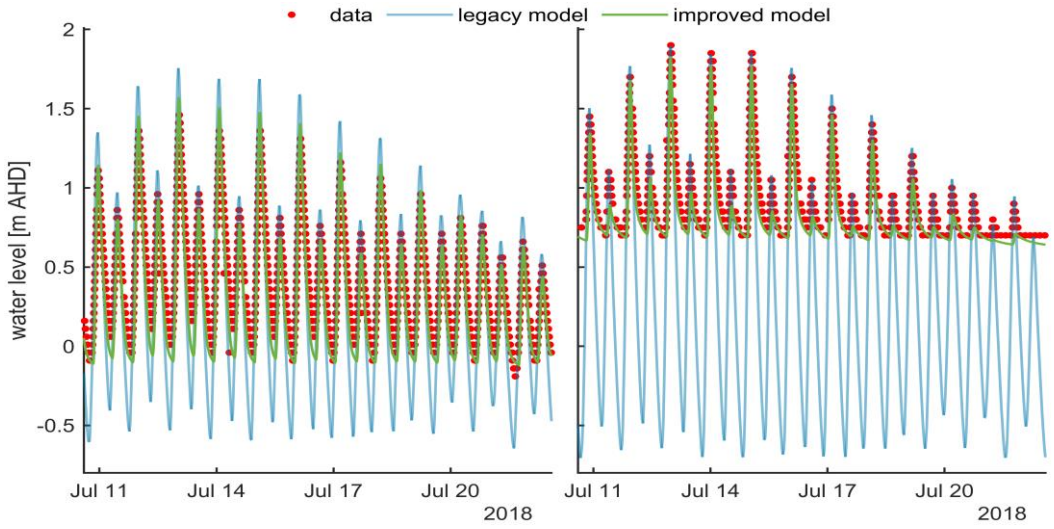


FIGURE 8-2 COMPARISON OF THE LEGACY AND IMPROVED NUMERICAL MODELS AGAINST MEASUREMENTS IN THE UPPER LOGAN ESTUARY AT LOGAN VILLAGE (LEFT) AND THE UPPER ALBERT ESTUARY AT WOLFFDENE (RIGHT)

8.3.2 ADCP transects

To further demonstrate the model's ability to simulate the hydrodynamics within the Logan River Estuary, comparisons between measured and modelled flows and currents adjacent the MOA were undertaken. The measurements were collected using a downward facing Acoustic Doppler Current Profiler (ADCP) (See Section 6.3). The ADCP was attached to a small unmanned vessel and towed alongside the crewed field boat as depicted in Figure 8-3. The ADCP was continuously towed across the estuary throughout the ebb-flood cycle (10+ hours) during both neap and spring tides.



FIGURE 8-3 DOWNWARD FACING ADCP MOUNTED ON AN UNMANNED VESSEL AND TOWED ALONGSIDE A FIELD BOAT

Measured and modelled flows through the Logan River Estuary adjacent the MOA are presented together in Figure 8-4. The figure demonstrates how the model adequately simulates the flows during ebb-flood and spring-neap tides, with a slight overprediction in the peak flood-tide flows and a slight under prediction in the peak ebb-tide flows.

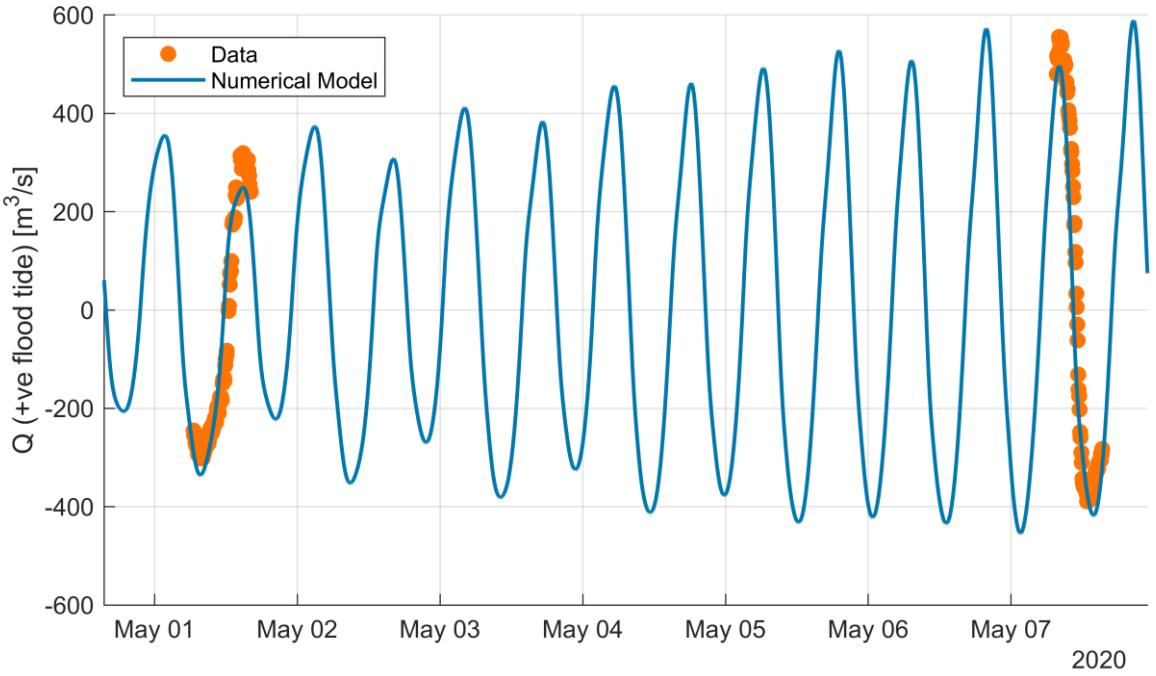


FIGURE 8-4 COMPARISION BETWEEN MEASURED AND MODELLED FLOWS THROUGH THE LOGAN RIVER ESTUARY ADJACENT TO THE MOA

Measured and modelled currents through the Logan River Estuary adjacent the MOA are presented together in Figure 8-5 to Figure 8-8. The figures consist of three panels.

The first panel, which occupies the left side of the figure, is an aerial image in greyscale overlain with coloured arrows. The arrows represent the measured and modelled depth averaged currents. The line of arrows forms the line traversed by the field boat with the ADCP in tow (the transect). For all transects presented, the transects start on the southern bank and end just upstream of Serpentine Creek. The position within the tidal cycle when the transect was conducted is indicated within the top left corner of the first panel.

The second and third panels occupy the right side of the figure and depict the transects in profile view. The two panels respectively depict the measured and modelled currents throughout the water column and across the estuary. The colour scale is representative of the magnitude of the current velocities. As the ADCP is unable to measure the currents immediately below the water surface or immediately above the bed, the rendered areas are not equivalent between the two panels. Nevertheless, the exact location of the surface and bed is measured and indicated with a dotted black line. The near-surface and near-bed areas were accounted for in calculating the flows used in the flow calibration.

The first panels in Figure 8-5 to Figure 8-8 indicate how the magnitude and direction of the depth averaged currents across the estuary are consistent between those measured and those modelled for various stages within the ebb-flood and spring-neap tidal cycles. The second and third panels in the figures indicate how the measured and modelled currents are distributed equivalently throughout the water column and across the transect.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

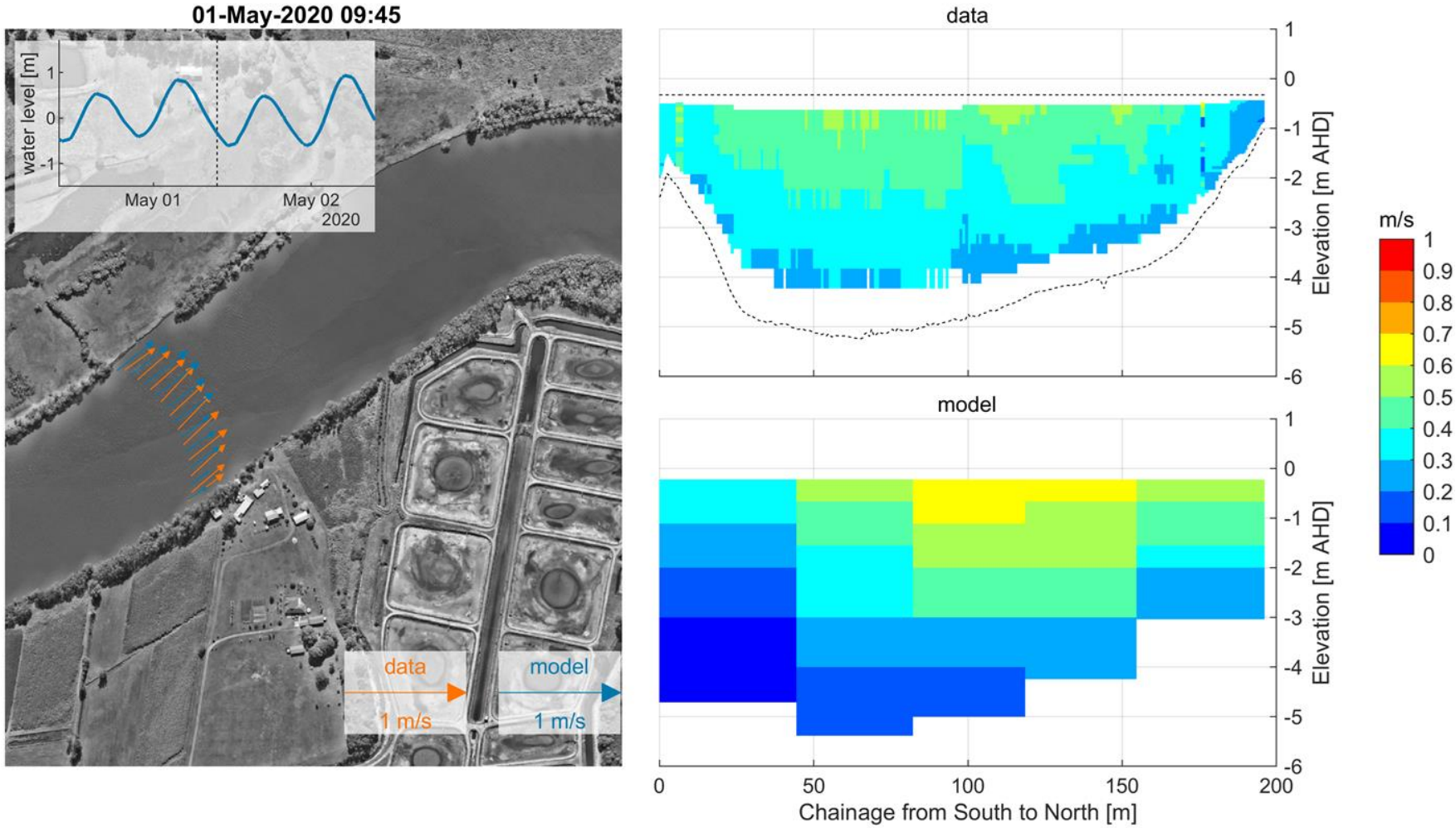


FIGURE 8-5 COMPARISON BETWEEN MEASURED AND MODELLED EBB TIDE CURRENTS ADJACENT TO THE MOA DURING NEAP TIDES

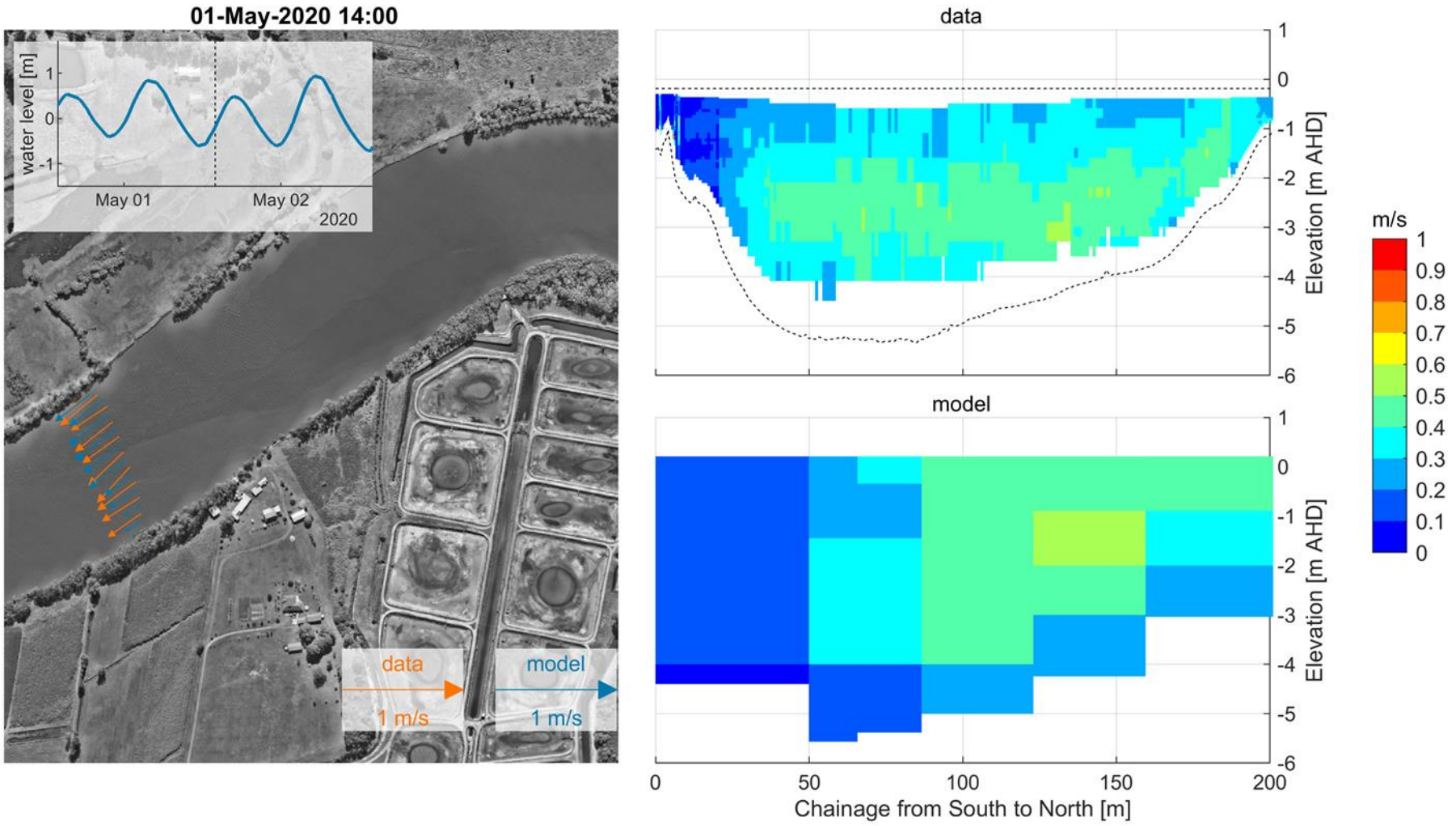


FIGURE 8-6 COMPARISON BETWEEN MEASURED AND MODELLED FLOOD-TIDE CURRENTS ADJACENT TO THE MOA DURING NEAP-TIDES

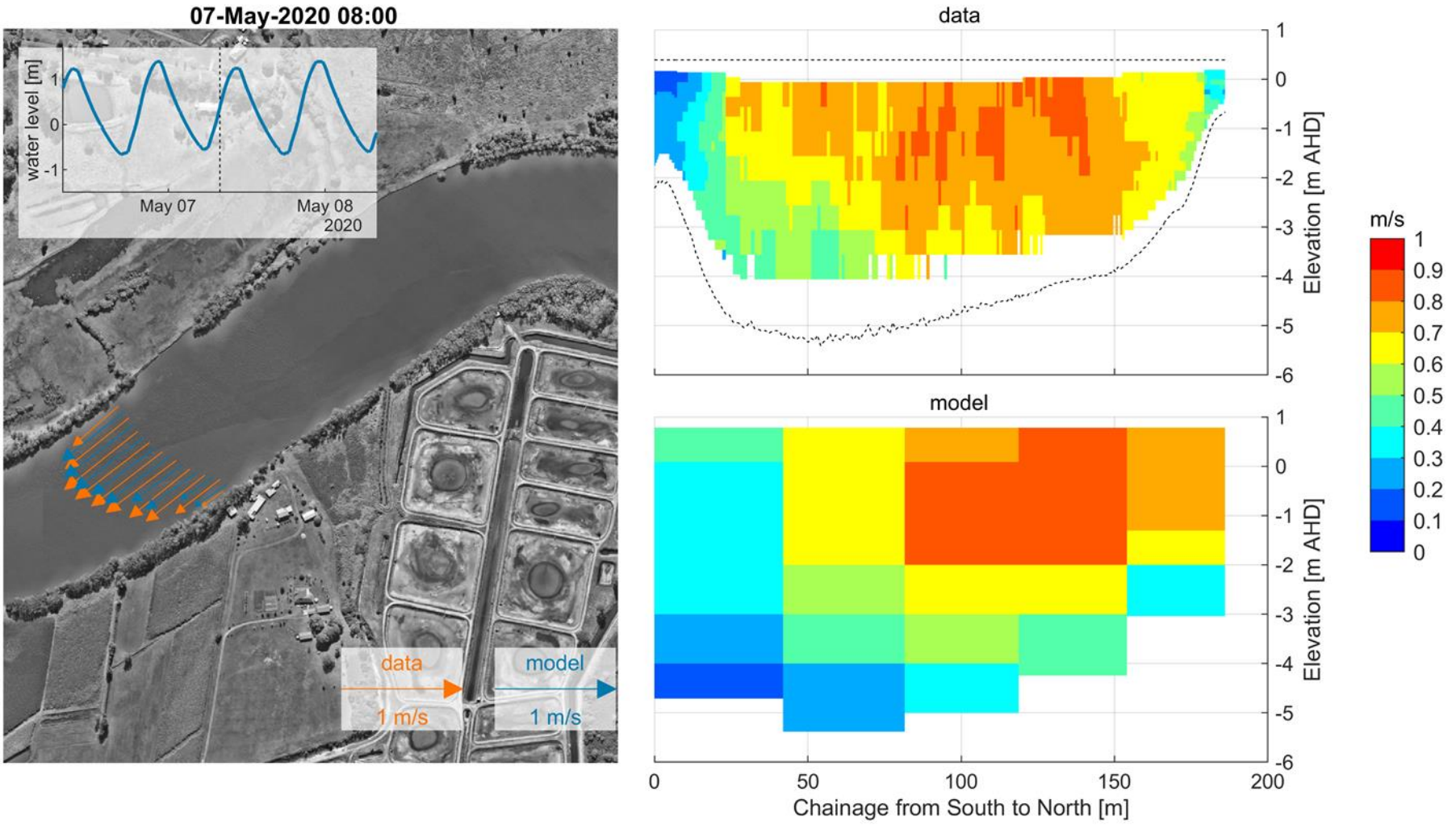


FIGURE 8-7 COMPARISON BETWEEN MEASURED AND MODELLED FLOOD-TIDE CURRENTS ADJACENT TO THE MOA DURING SPRING-TIDES

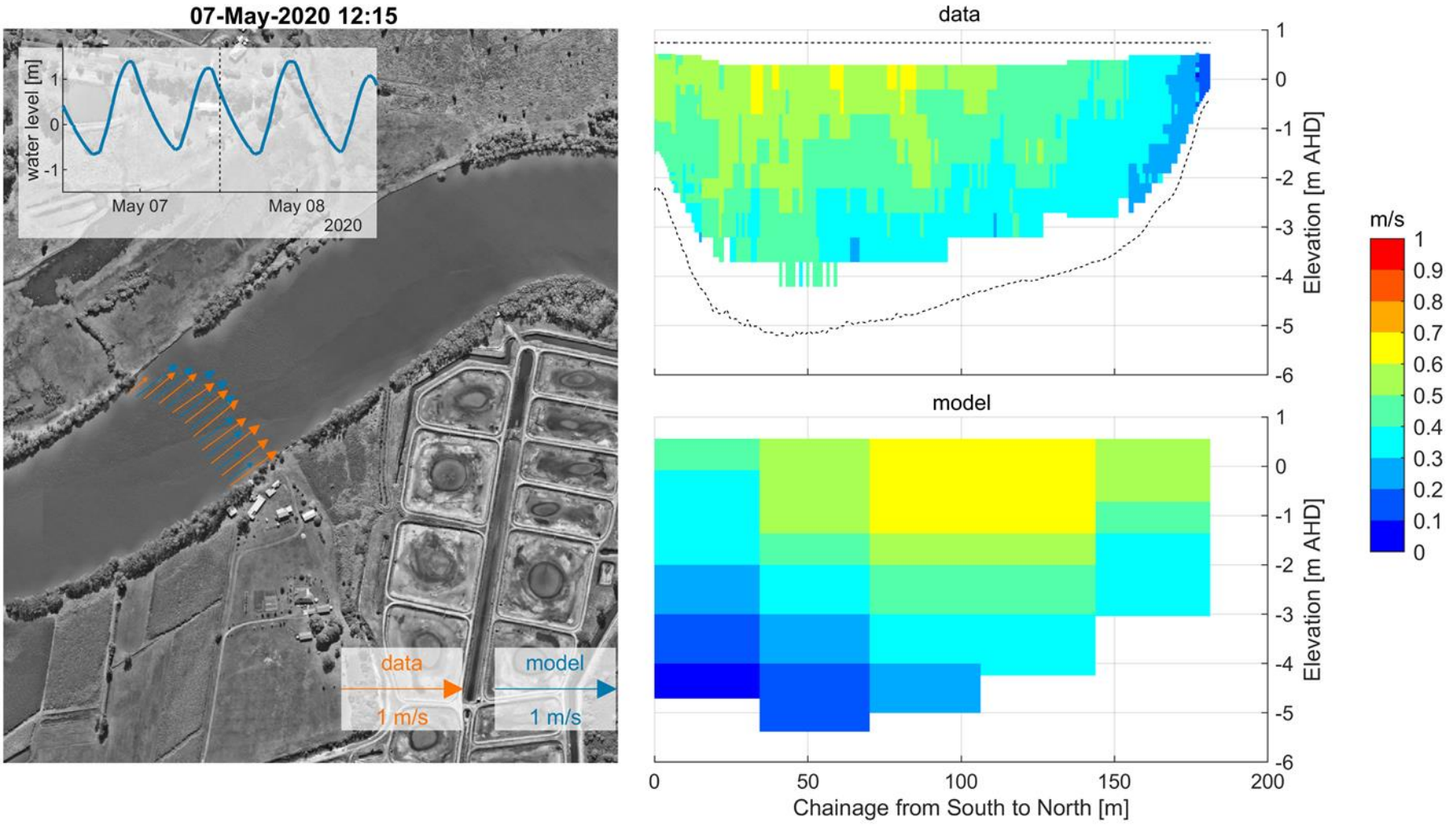


FIGURE 8-8 COMPARISON BETWEEN MEASURED AND MODELLED EBB-TIDE CURRENTS ADJACENT TO THE MOA DURING SPRING-TIDES

8.4 Water Quality Model Validation

Water Technology has been enhancing this model since 2018. Model results for the Logan-Albert estuary, as presented in Figure 8-9 to Figure 8-21, were judged by an independent expert review panel in 2019 to be of a high standard.

Figure 8-9 - Figure 8-21 are plots depicting the respective longitudinal distributions of dissolved oxygen, total nitrogen and total phosphorus in the Logan Estuary. The observations were collected as part of the Environmental Health Monitoring Program. Water Technology performed the numerical modelling as part of the 2018-2019 Healthy Land and Water report carding initiative. The plots indicate how the location of the Loganholme Wastewater Treatment Plant generally coincides with the minima in dissolved oxygen and the maxima in nutrient concentrations. It is understood that these concentrations are reflective of the sheer volume of discharge from the Loganholme treatment plant (67 ML/day). Note that the proposed MOA is located between the EHMP sites E00212 and E00211 (See Figure 6-2).

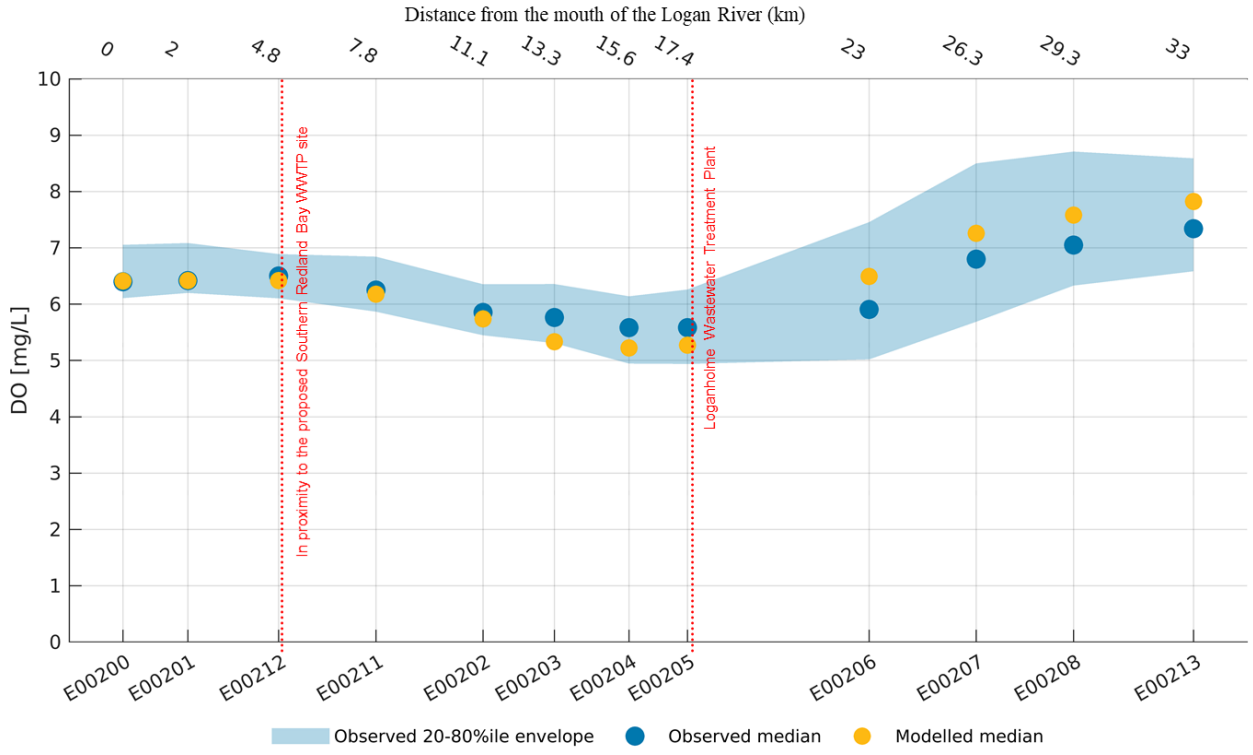


FIGURE 8-9 OBSERVED (EHMP) AND MODELLED DO IN THE LOGAN ESTUARY, 2018-2019

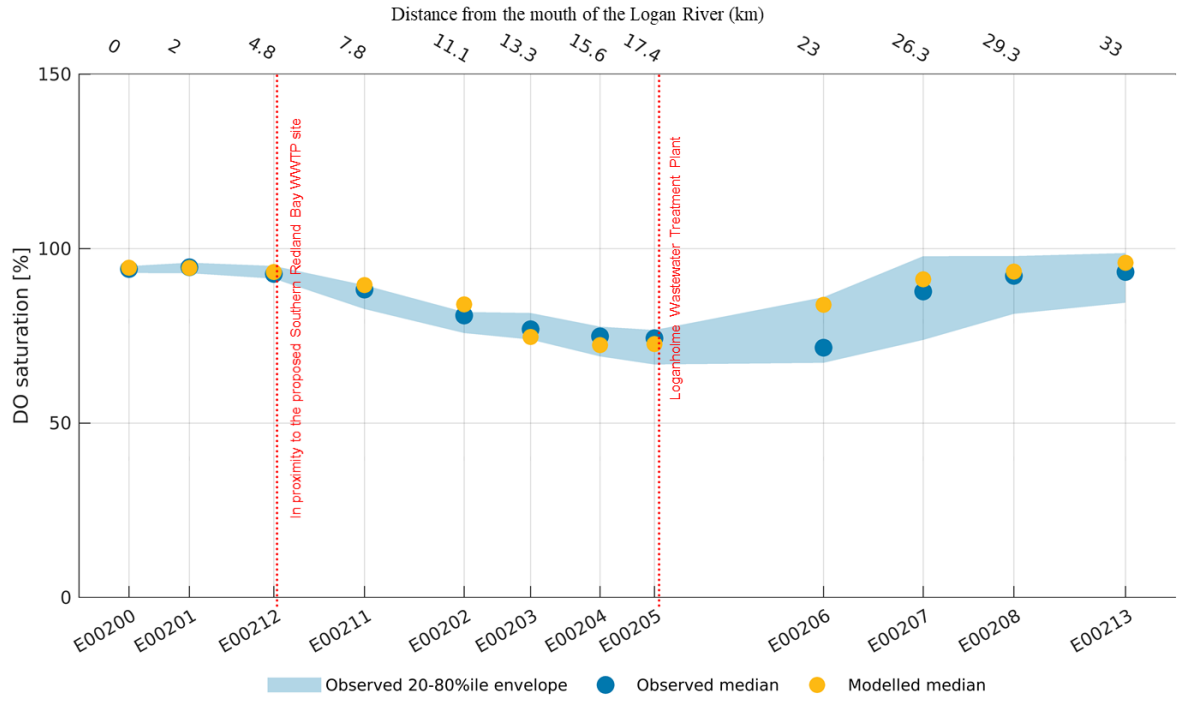


FIGURE 8-10 OBSERVED (EHMP) AND MODELLED DO SATURATION IN THE LOGAN ESTUARY (2018-2019)

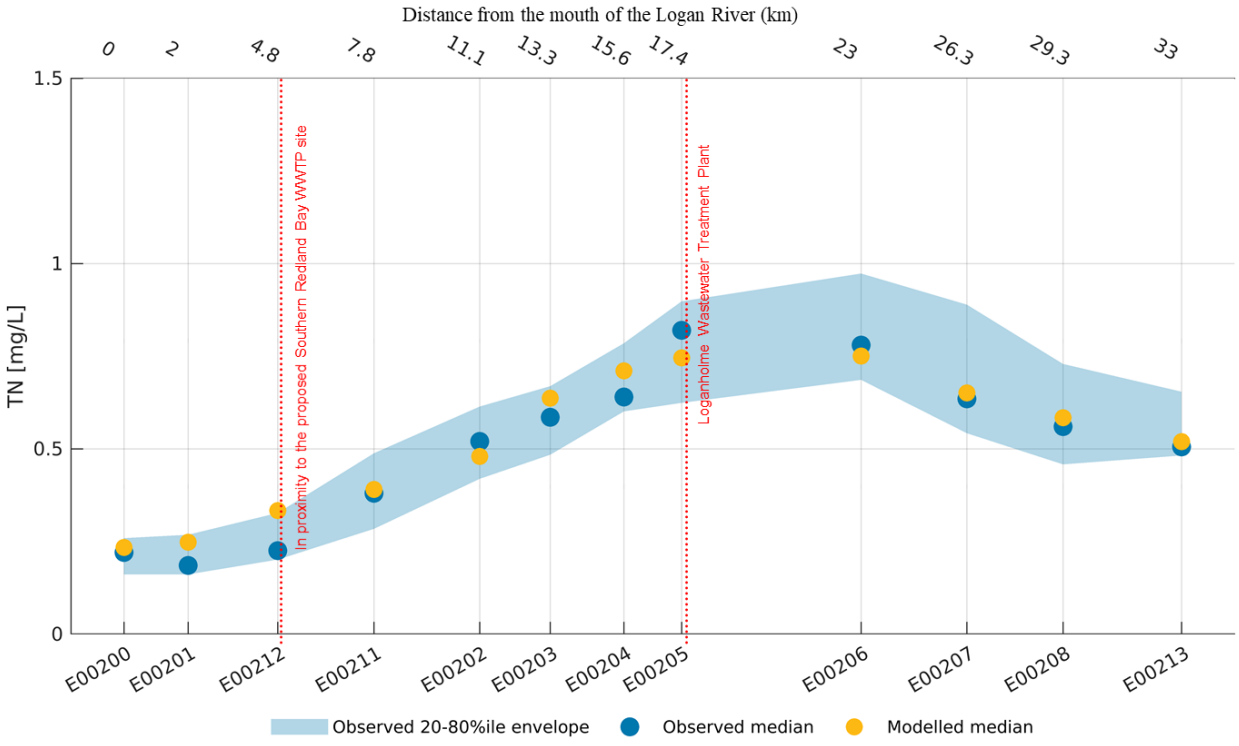


FIGURE 8-11 OBSERVED (EHMP) AND MODELLED TOTAL NITROGEN IN THE LOGAN ESTUARY (2018-2019)

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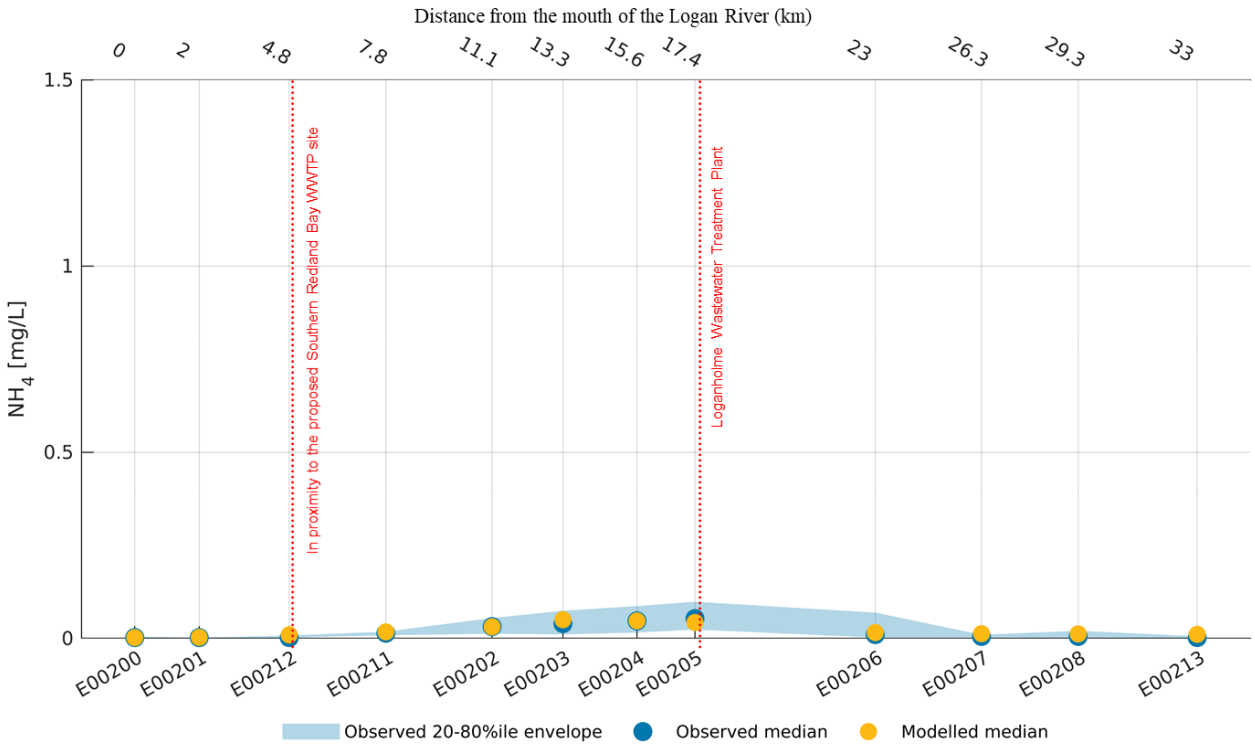


FIGURE 8-12 OBSERVED (EHMP) AND MODELLED AMMONIA IN THE LOGAN ESTUARY (2018-2019)

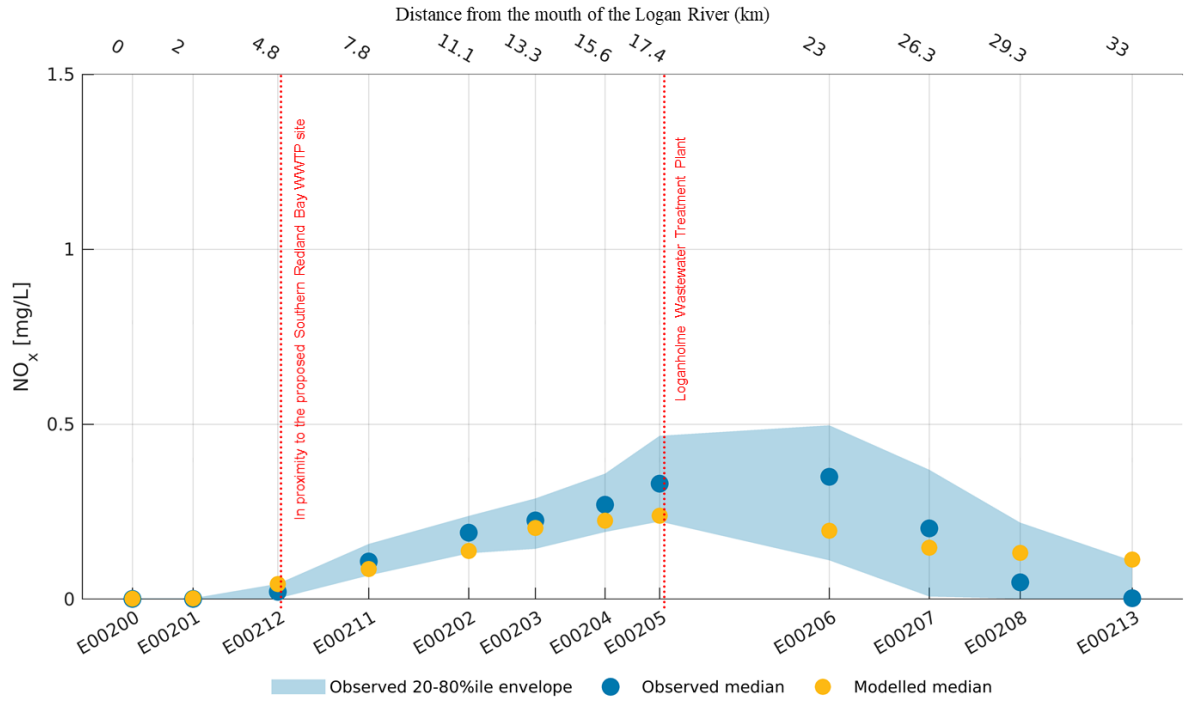


FIGURE 8-13 OBSERVED (EHMP) AND MODELLED NOX IN THE LOGAN ESTUARY (2018-2019)

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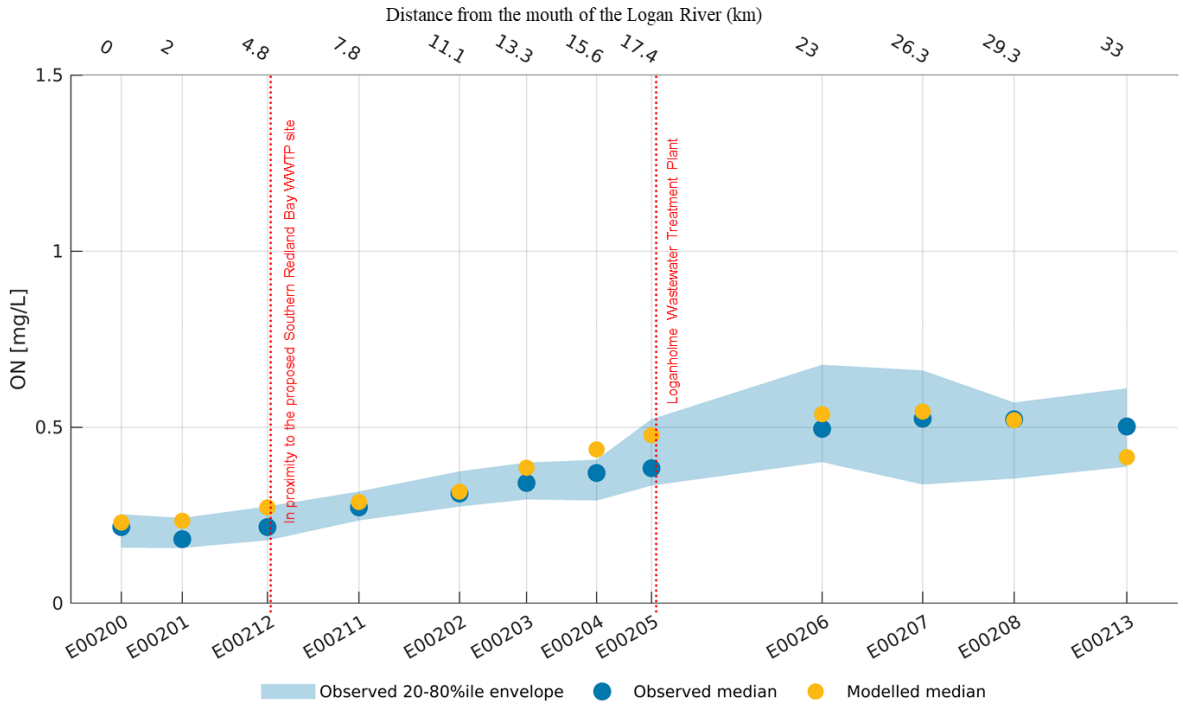


FIGURE 8-14 OBSERVED (EHMP) AND MODELLED ON IN THE LOGAN ESTUARY (2018-2019)

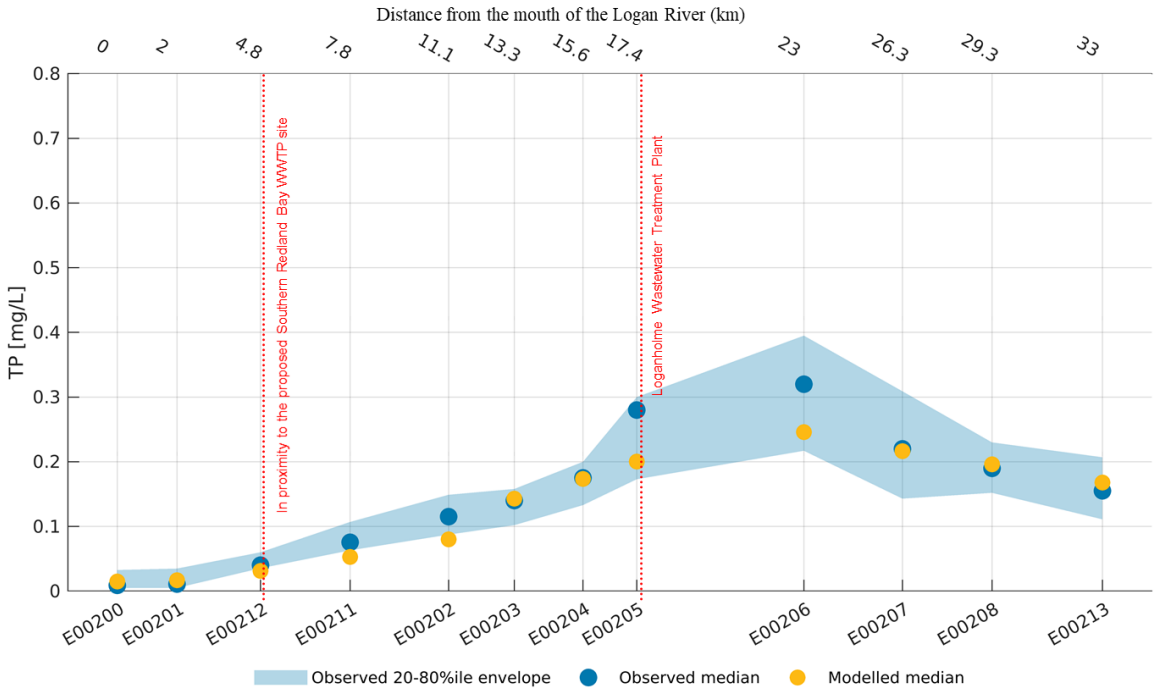


FIGURE 8-15 OBSERVED (EHMP) AND MODELLED TOTAL PHOSPHORUS IN THE LOGAN ESTUARY, 2018-2019

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

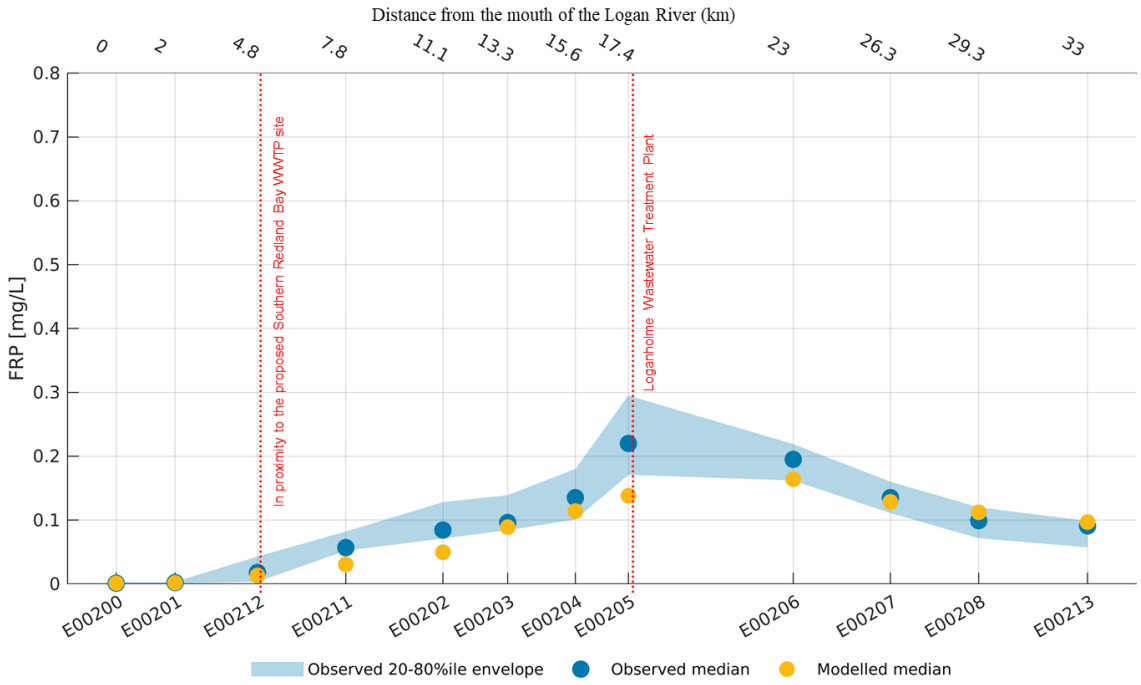


FIGURE 8-16 OBSERVED (EHMP) AND MODELLED FRP IN THE LOGAN ESTUARY (2018-2019)

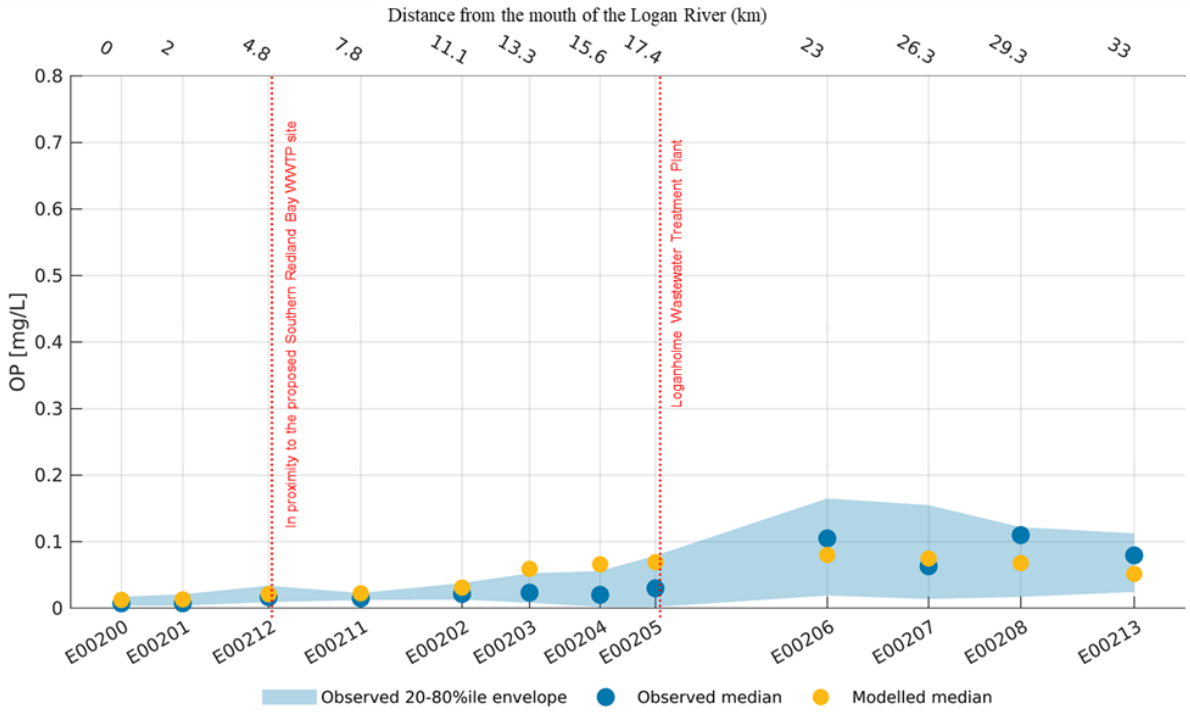


FIGURE 8-17 OBSERVED (EHMP) AND MODELLED OP IN THE LOGAN ESTUARY (2018-2019)

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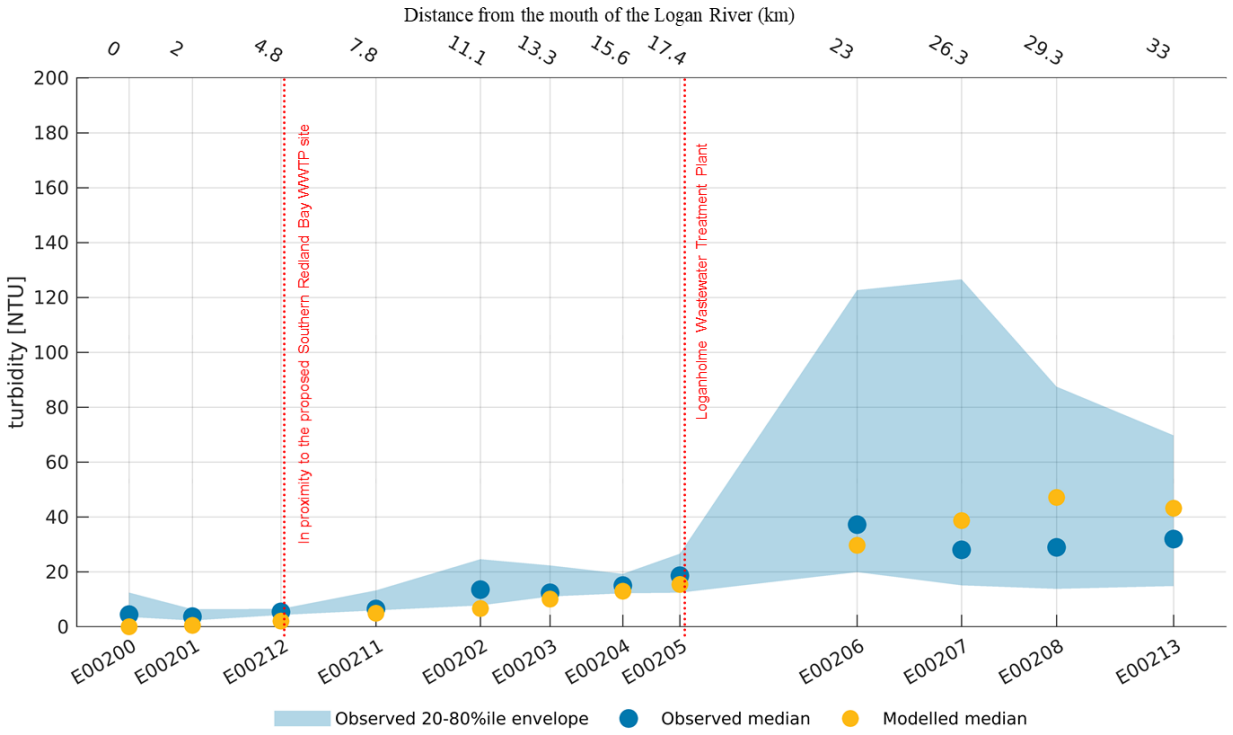


FIGURE 8-18 OBSERVED (EHMP) AND MODELLED TURBIDITY IN THE LOGAN ESTUARY (2018-2019)

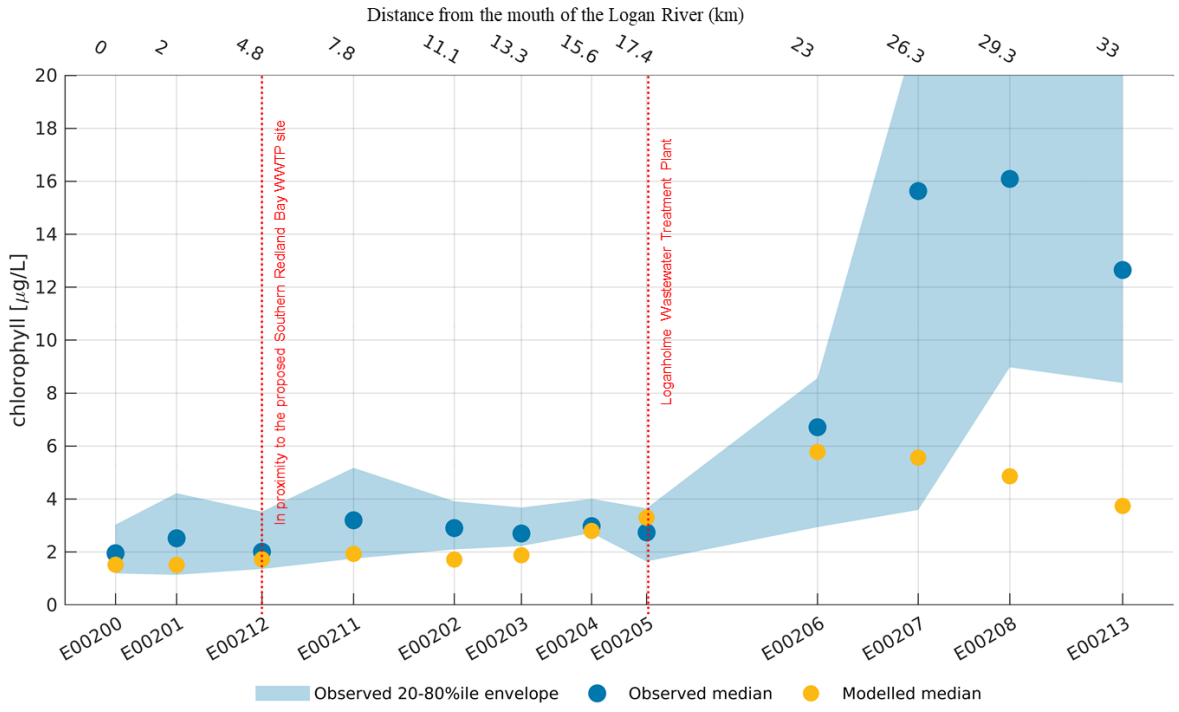


FIGURE 8-19 OBSERVED (EHMP) AND MODELLED CHLOROPHYLL-A IN THE LOGAN ESTUARY (2018-2019)

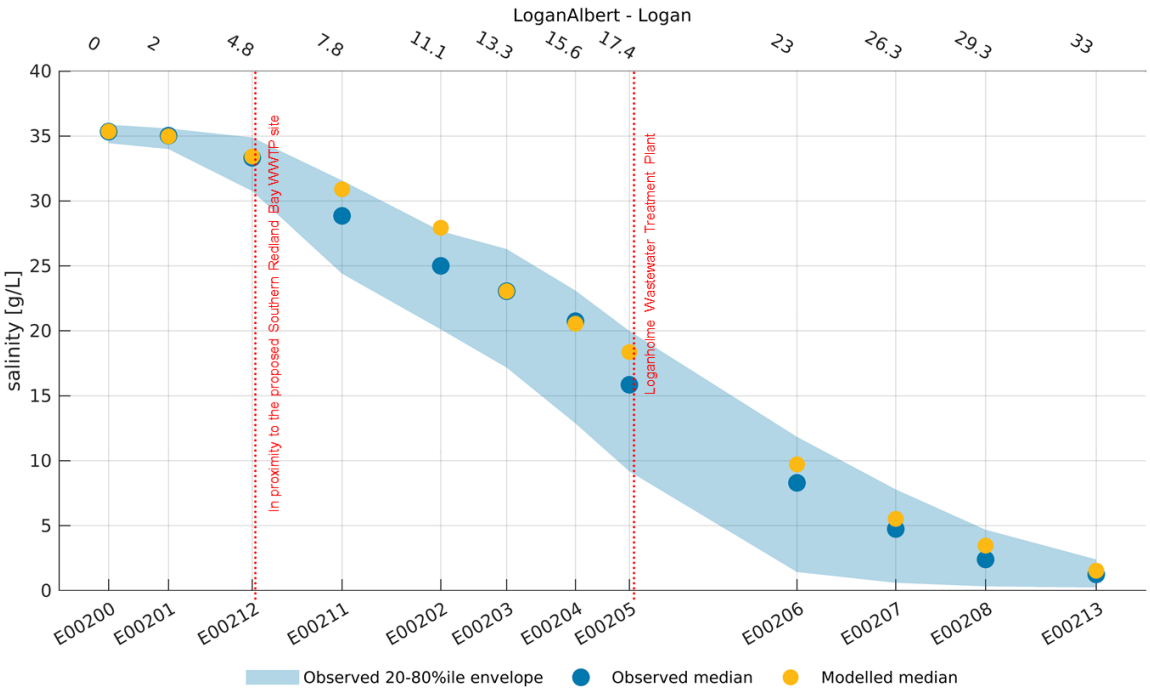


FIGURE 8-20 OBSERVED (EHMP) AND MODELLED SALINITY IN THE LOGAN ESTUARY (2018-2019)

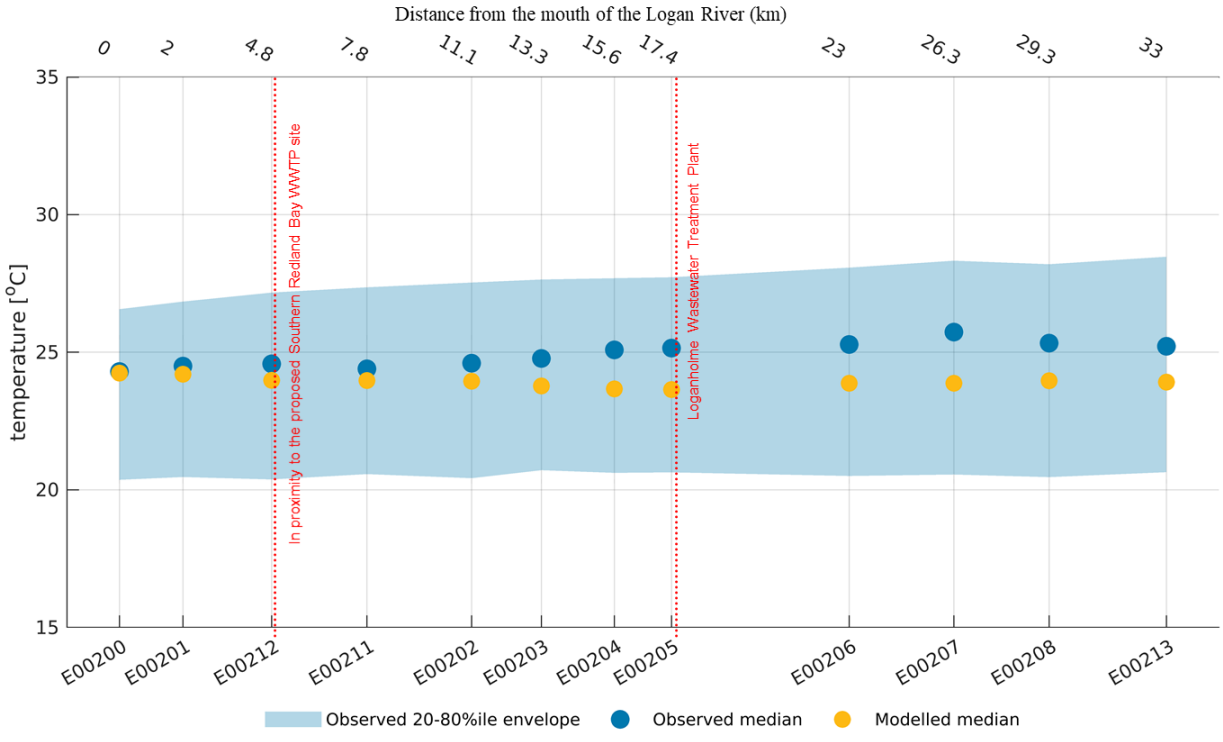


FIGURE 8-21 OBSERVED (EHMP) AND MODELLED TEMPERATURE IN THE LOGAN ESTUARY (2018-2019)

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

The outcomes for the refined Logan-Albert River model were further assessed by comparing simulated temperature, salinity, dissolved oxygen and nutrient results with measurements collected during the course of study. The EHMP locations depicted in the Logan River are immediately upstream (E00211) and downstream (E00212) of the site. The monitoring locations are displayed in Figure 8-1.

The model was capable of adequately representing the water quality processes in the Logan River in the vicinity of the MOA. The following commentary is based on upstream (E00211) and downstream (E00212) EHMP data.

The comparison between simulated and measured temperature at the two selected EHMP locations is presented in Figure 8-22. The figure demonstrates that the model accurately simulates water temperature during warm and cool periods.

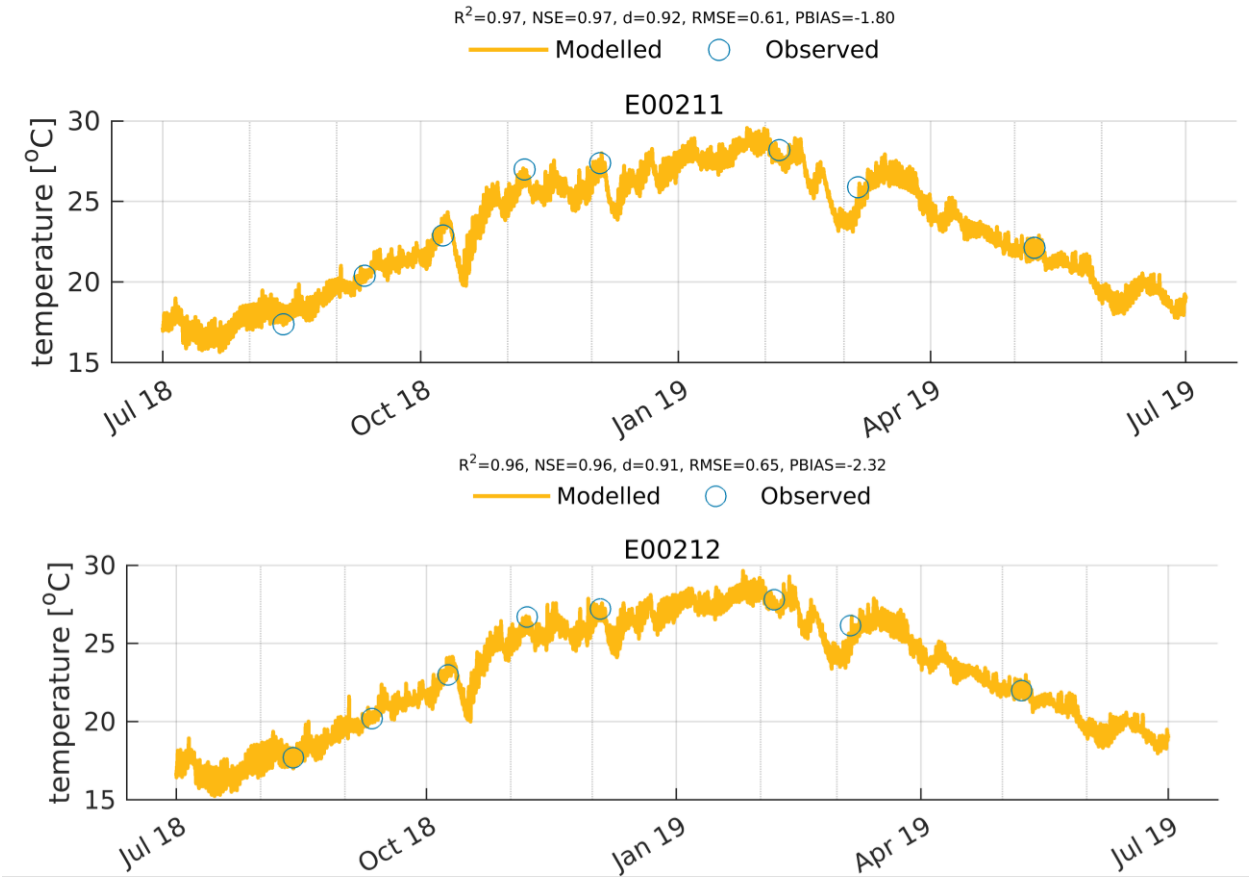


FIGURE 8-22 COMPARISON BETWEEN SIMULATED AND MEASURED TEMPERATURE

The comparison between simulated and measured salinity at the two chosen EHMP sites is presented in Figure 8-23. The high measurement in March is likely spurious. The prediction of salinity was an accurate representation of reality.

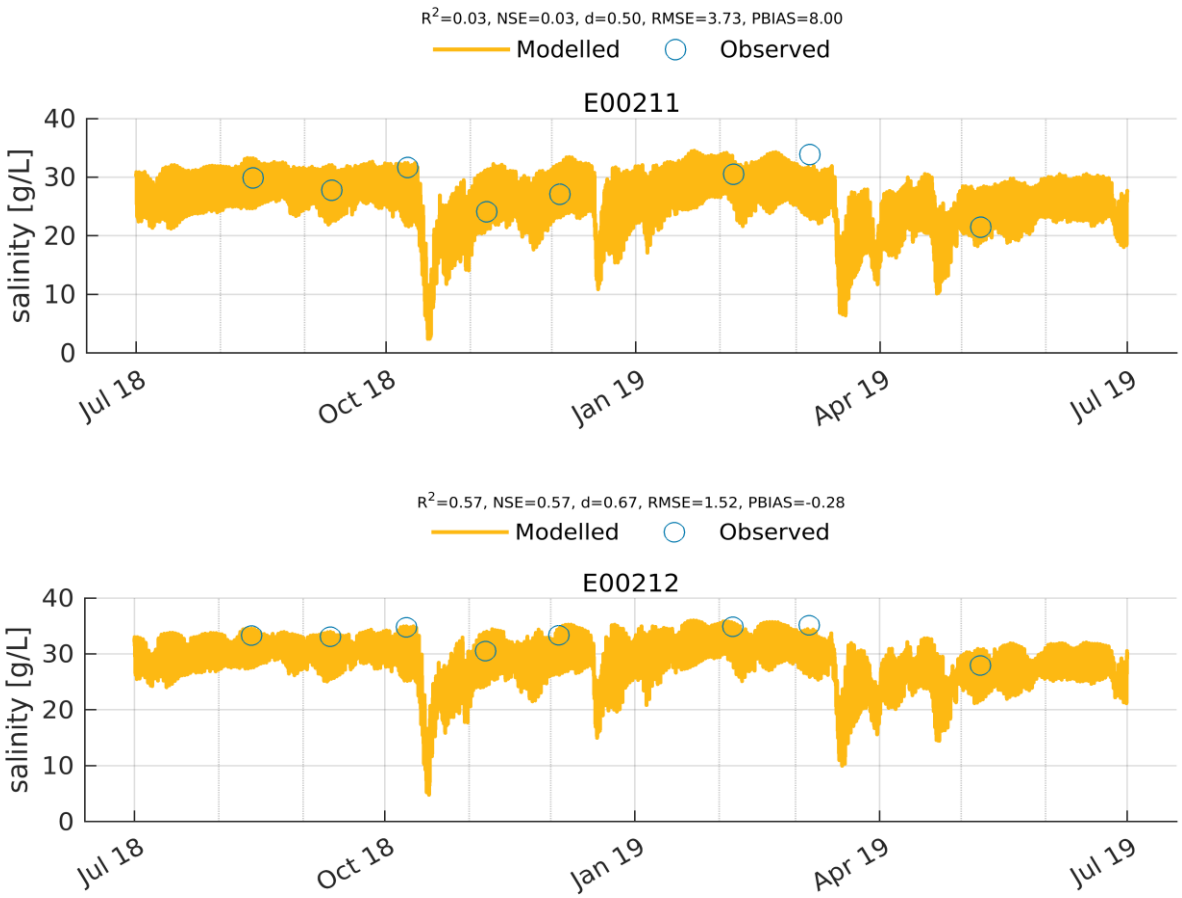


FIGURE 8-23 COMPARISON BETWEEN SIMULATED AND MEASURED SALINITY

The comparison between the simulated and measured dissolved oxygen at the two chosen sites is presented in Figure 8-24. The slight discrepancies are attributable to minor misrepresentations of the oxygen contributions from photosynthesizing organisms within suspension and on the bed. In general, the prediction of DO was an accurate representation of reality.

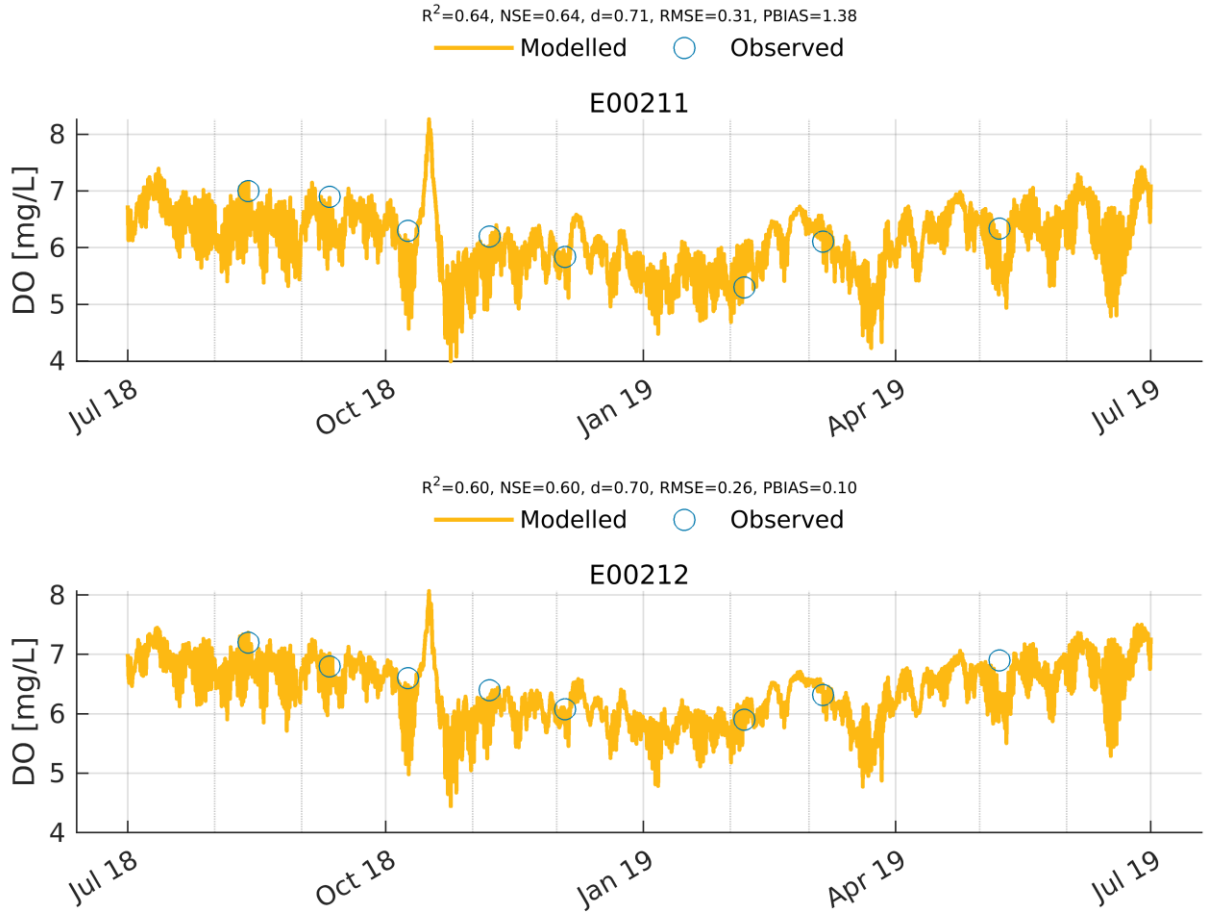


FIGURE 8-24 COMPARISON BETWEEN SIMULATED AND MEASURED DISSOLVED OXYGEN

The comparisons between the simulated and measured total nitrogen at the EHMP sites are presented in Figure 8-25. The model slightly overpredicts the total nitrogen trend, especially in the month of March.

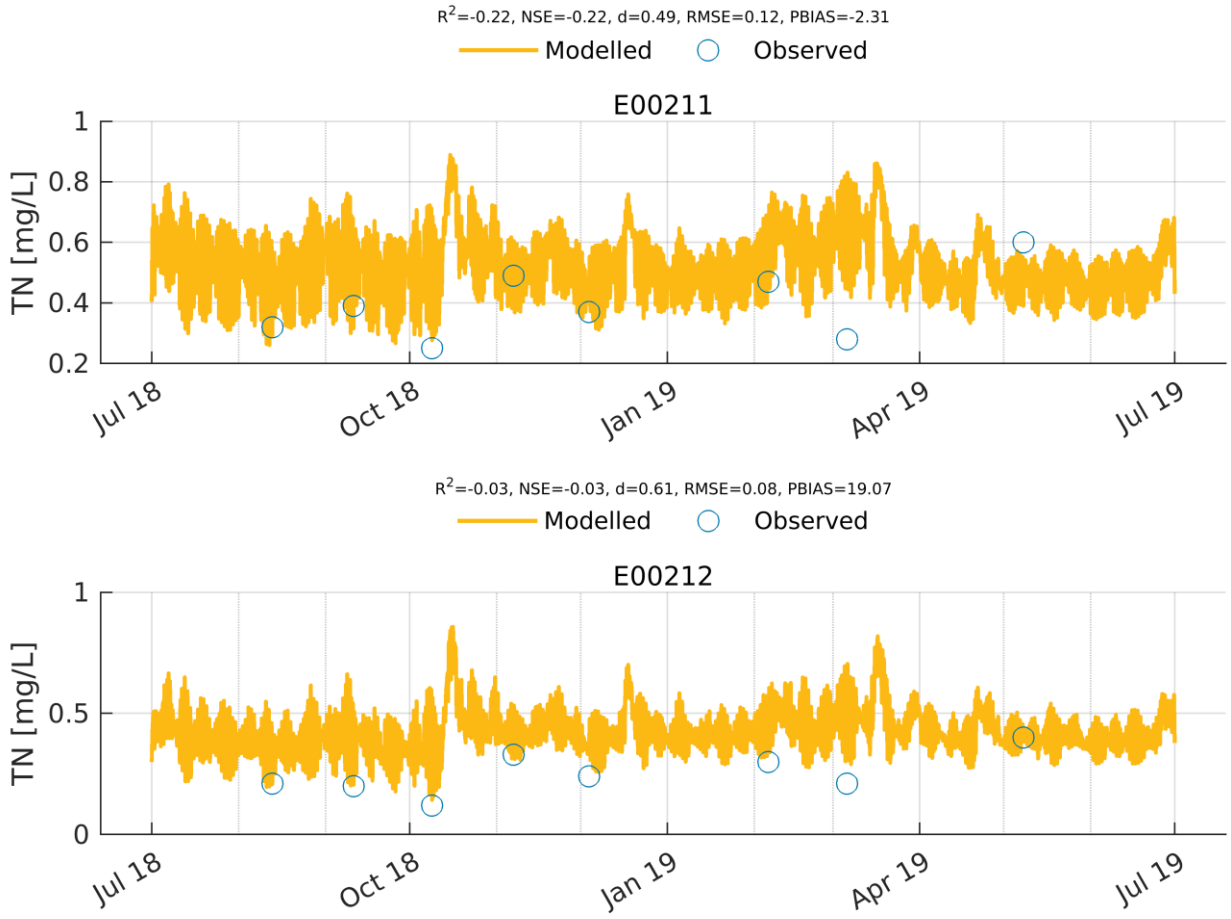


FIGURE 8-25 COMPARISON BETWEEN SIMULATED AND MEASURED TOTAL NITROGEN

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

The comparisons between simulated and measured total phosphorus at the chosen EHMP sites are presented in Figure 8-26. The model reproduces the general trend of total phosphorus through the year, but slightly overpredicts concentrations in March.

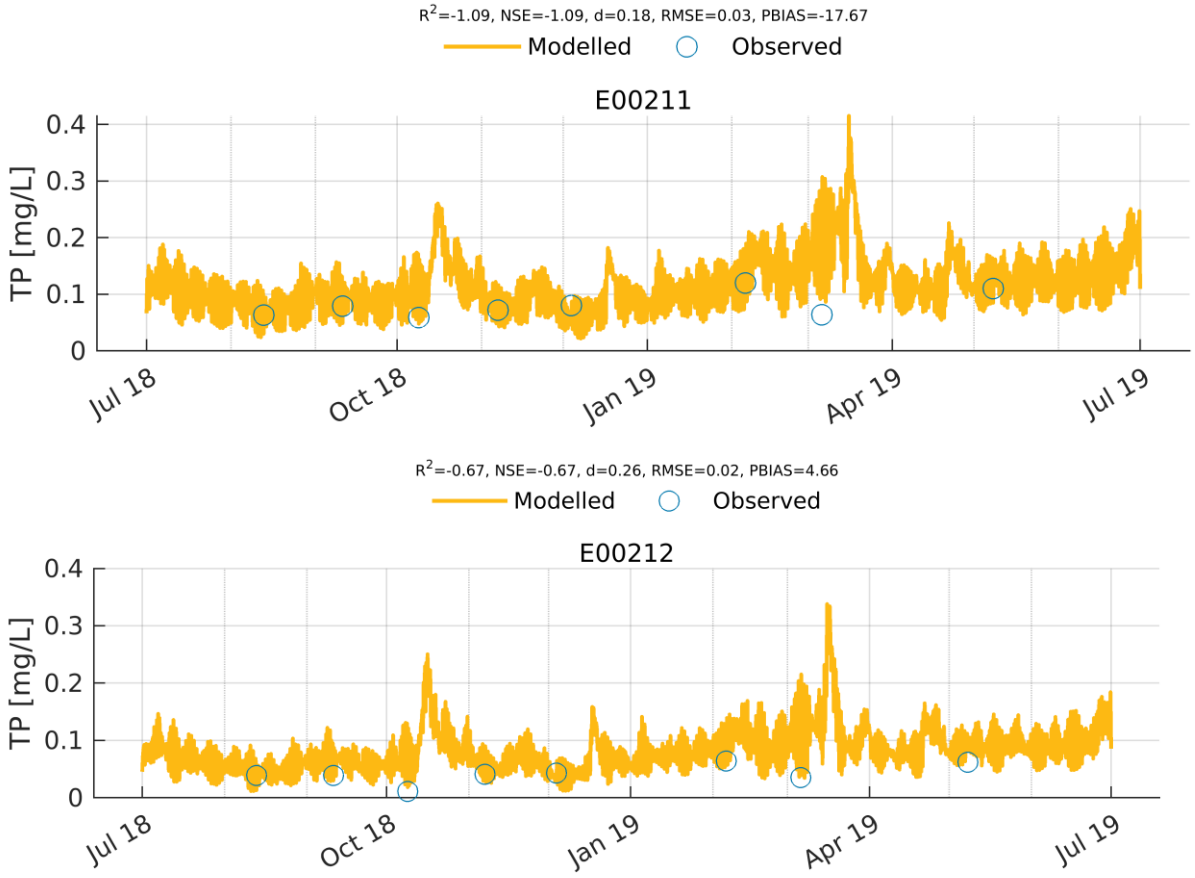


FIGURE 8-26 COMPARISON BETWEEN SIMULATED AND MEASURED TOTAL PHOSPHORUS

8.5 Discussion

A baseline data collection campaign was conducted in the Logan River Estuary to establish background conditions and assist with development of the numerical model. Following an extensive data collection campaign, the hydrodynamic and water quality model was successfully calibrated.

The following conclusions can be drawn from the data collection program and modelling works:

- Water quality was slightly poorer with increasing proximity to the Loganholme WWTP outfall, this includes:
  - Higher total nitrogen and total phosphorus levels;
  - Lower dissolved oxygen; and
  - Increasing turbidity.
- It is understood that lower DO and higher nutrient concentrations in the Logan River are reflective of the sheer volume of discharge from the Loganholme WWTP (predicted to be approximately 67 ML/day upon Stage 7 upgrade), which will be well over 33 times the discharge volume from the proposed Southern Redland Bay WWTP.
- Water quality was slightly better during the colder months, which is likely due to lower wind speeds, cooler temperatures and lower rainfall (hence less diffuse loads from the catchment) experienced during winter.

- The model accurately represents water quality, current speeds, direction, fluxes and water level in the Logan River, which forms a good basis for the impact assessments presented in Section 9 for the developed case.

9 ESTUARINE IMPACT ASSESSMENTS

9.1 Water Quality

9.1.1 Overview

To provide insights into the expected changes in water quality within the Logan River Estuary attributable to the SRBWWTP, comparisons between the following three scenarios/cases were made:

- **An existing case,** which is the undeveloped case wherein the site is in its existing state;
- **A base case,** with fully constructed mangrove/salt marsh habitat in the MOA and no recycled water discharge from the proposed WWTP; and
- **A developed case,** this being the base case with recycled water discharged from the proposed WWTP.

The three scenarios were used to investigate the extent to which the MOA would change water quality within the Logan Estuary and the net effect when discharges of recycled water from the proposed WWTP were included. It was assumed for the base and developed cases that the mangroves in the MOA were fully established. For the developed case, it was assumed the SRBWWTP was fully operational.

The assessment was performed by extending the existing TUFLOWFV estuary model, described previously in Section 8, to include the proposed MOA. The inlet and outlet structures and the excavated bathymetry within the MOA had been designed to facilitate the colonisation by mangroves over the designated areas (See 'Hydrodynamic Modelling for Culvert Sizing' report). The percentage of time for which the various areas of the MOA are expected to be inundated is presented in Figure 9-1. The values were derived by analysing a one (1) month modelled period. As evident in the figure, the percentage times inundated are amenable to mangrove colonisation, and in the upper regions, salt marsh colonisation. The ground elevations and the time varying water levels, which are dependent on the configuration of the inlet and outlet culverts, were carefully considered during the culvert design works (See Hydrodynamic Modelling for Culvert Sizing report by Water Technology). The percentage inundation times which are amenable to the colonisation by locally native species were derived from the surveyed extents of existing intertidal vegetation and measured water levels within the adjacent Logan River Estuary.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

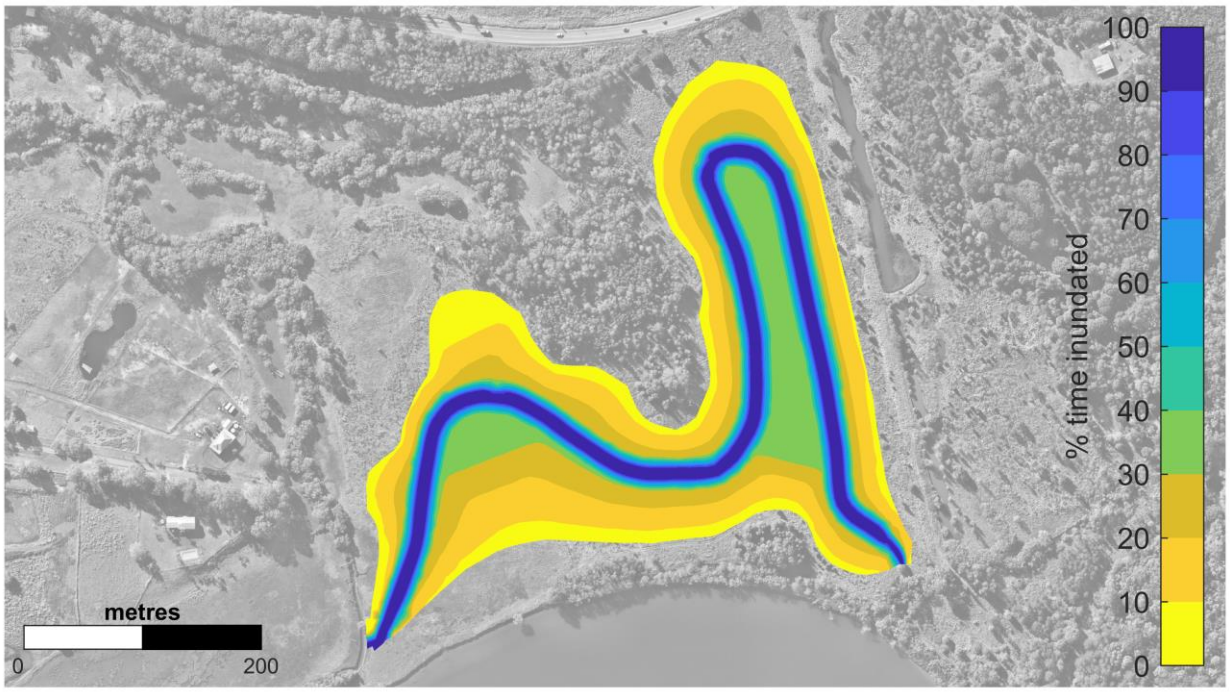


FIGURE 9-1 MODELLED INUNDATION TIMES (PERCENTAGE) WITHIN THE MOA. INUNDATION TIMES BEYOND THE MOA HAVE NOT BEEN MAPPED

Nutrient removal within the MOA was modelled using nutrient demands (sinks) of dissolved nitrogen oxides and filterable reactive phosphorus. The nutrient uptake for the areas expected to be colonised by mangroves differed to those expected to be colonised by salt marsh. Nutrient uptake only occured when the respective elements within the model were inundated. Subsequently, more nitrogen was removed from cells which were inundated more often than those less often. Whilst the mechanism by which nutrients are removed may not be represented explicitly, the key processes are represented. The nutrients removed in the developed case were slightly higher than for the base case, reflective of the additional nutrients available for uptake.

The modelled nutrient demands within the MOA are presented in Table 9-1. The values were calculated over the same 1 (one) month period as that used for the box and whisker plots presented later within this section. The modelled rates of nitrogen removal are conservative, being slightly lower than those derived in Section 3.3. The modelled rates of phosphorus removal are slightly higher than those in Section 3.3.

TABLE 9-1 MODELLED REMOVAL OF NUTRIENS WITHIN THE MOA FOR DEVELOPED CASE

Areas within MOA	Nitrogen		Phosphorus	
	kg/ha/day	kg/day	kg/ha/day	kg/day
Mangroves	0.6	4.5	0.1	0.9
Saltmarsh	0.2	0.5	0.04	0.1
Combined	0.5	5.0	0.09	1.0

For the developed case, recycled water was modelled as discharging continuously into the subtidal channel at the north east corner of the MOA at 28 L/s or 2.4 ML/day. The subtidal channel will never completely drain due to the elevation of the outlet culvert, therefore treated water will always be diluted to some extent when released into the MOA. The total nitrogen and phosphorus concentrations in the discharge were constant at

3 mg/L and 1 mg/L, resulting in loads of 7.2 kg/day for nitrogen and 2.4 kg/day for phosphorus. The values are consistent with those presented in Table 3-1. As presented in Figure 9-2, the modelled discharged nutrients consisted principally of the inorganic fractions. Whilst the speciation of the nutrients discharged from the proposed WWTP will likely, to an extent, vary temporally, the values adopted (Figure 9-2) are assumed representative of the future operations and are consistent with those provided by Stantec's 'Southern Redland Bay (Shoreline) WWTP – Effluent Characterisation Technical Memorandum'. According to Stantec's memorandum, whilst the short term 50th percentile value for TN is assumed to be 3 mg/L as N as a discharge permit condition, speciation is applied as follows:

- Typical ammonia values are expected to be less than 3 mg/L as N;
- Nitrate is expected to typically be less than 1 mg/L as N; and
- Nitrite is expected to typically be less than 0.2 mg/L as N.

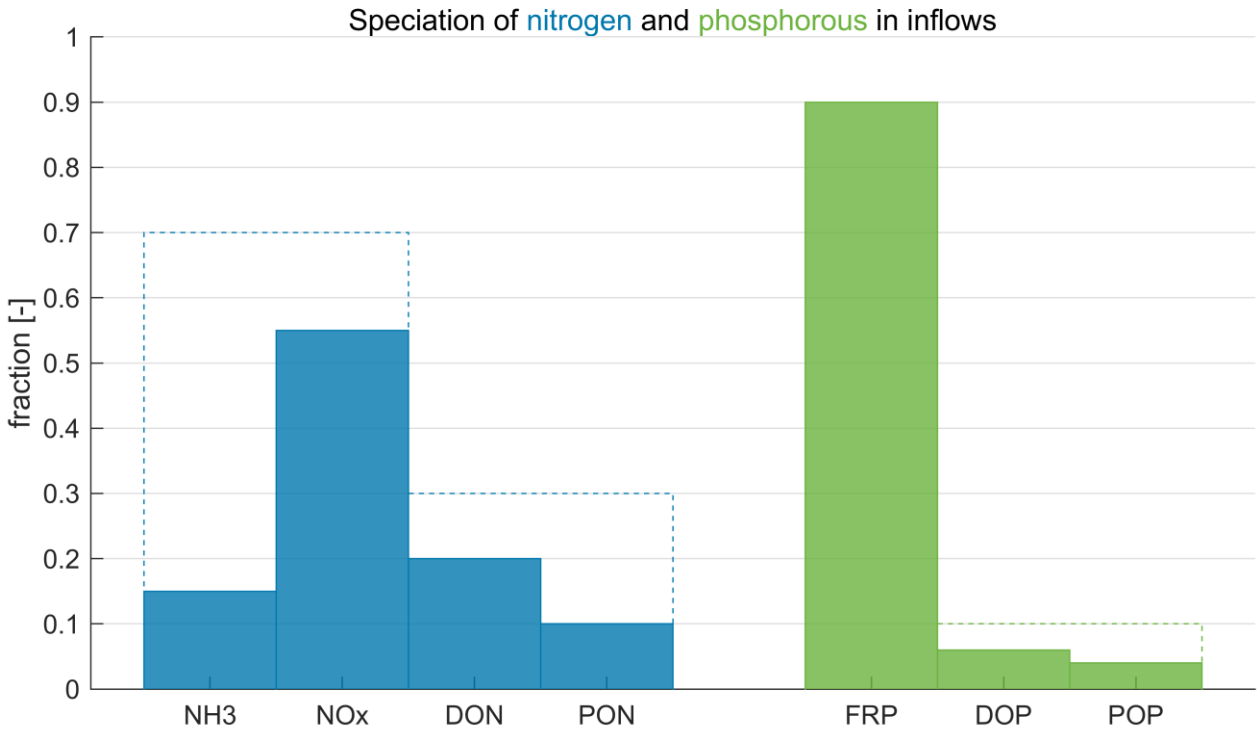


FIGURE 9-2 SPECIATION OF NUTRIENTS WITHIN THE MODELLED DISCHARGES OF THE PROPOSED WASTEWATER TREATMENT PLANT. INORGANIC NUTRIENTS ARE GROUPED AND PLOTTED TO THE LEFT OF THE RESPECTIVE ORGANIC NUTRIENTS.

The comparisons for water quality between existing, base and developed cases were made using 'box and whisker' plots generated from results extracted mid-channel in the Logan River Estuary adjacent to the mouth of Serpentine Creek. Results were extracted from the upper 0.5 m of the water column. The statistics, which form the basis of the plots, were calculated from model simulations spanning a one (1) month period during which there were no significant freshwater inflows from the catchment. Values extending more than 1.5 times the interquartile range from the median were plotted as circular markers.

As nitrogen is the limiting nutrient in the Logan River Estuary and salinity is critical to the estuarine nature of mangrove habitats, these two parameters are also presented using 2D map style plots. The plots indicate how the nitrogen and salinity is spatially distributed and how the distribution may change.

The results from the assessments are discussed in following sub sections.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

9.1.2 Salinity

Impacts may arise from changes in salinity influenced by the proposed recycled water discharge into the MOA which could subsequently influence mangrove growth and salinity in the Logan River. Existing salinity levels for the Logan River were incorporated into the Logan-Albert River model to provide a base case (Figure 9-3). Salinity levels within the proposed mangrove area (without recycled water discharge) were estimated to be to the order of ~ 30 g/L, which aligns with the levels in the adjacent Logan River.

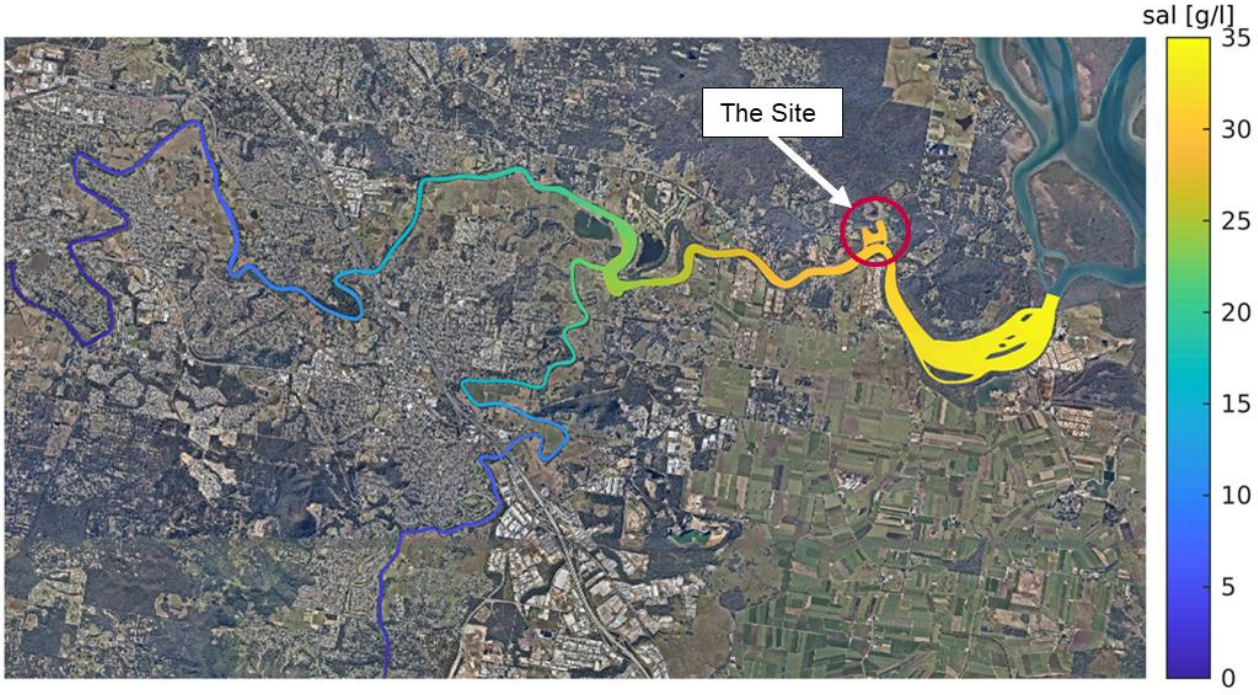


FIGURE 9-3 MEDIAN SALINITY DISTRIBUTION IN THE LOGAN RIVER – EXISTING (UNDEVELOPED) CASE

The expected changes to salinity within the Logan River Estuary in the vicinity of, and attributable to, the MOA are provided in Figure 9-4. It is evident that no significant change in salinity is expected when contextualised within the variation experienced throughout the tidal cycle during a month of dry weather.

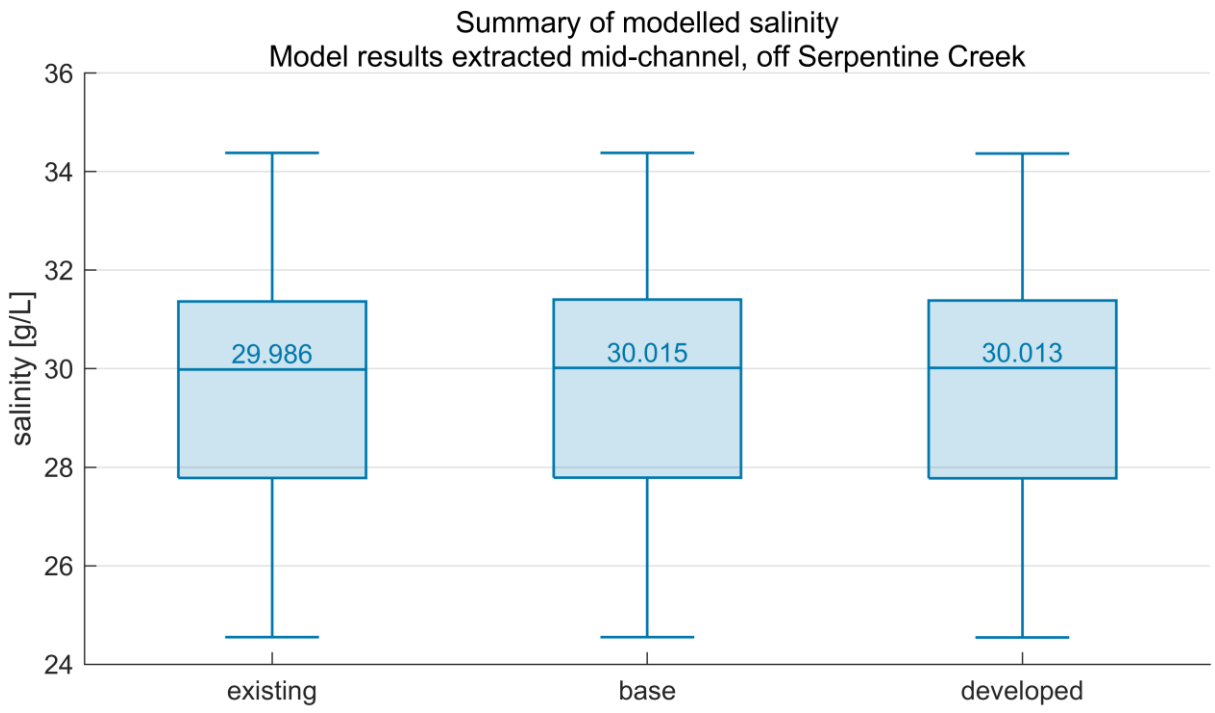


FIGURE 9-4 BOX PLOT OF MODELLED SALINITY

Results from the modelling showed minimal impacts from the proposed recycled water discharge into the MOA (Figure 9-5). The median salinity (~ 25 g/L) **within the mangroves** showed a slight decrease in the areas immediately surrounding the point of entry of recycled water. The slight decrease will not affect the establishment of mangroves or salt marsh. The discharge had **negligible impacts on salinity levels in the Logan River**, which were shown to remain at ~ 30 g/L (See Figure 9-4).

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

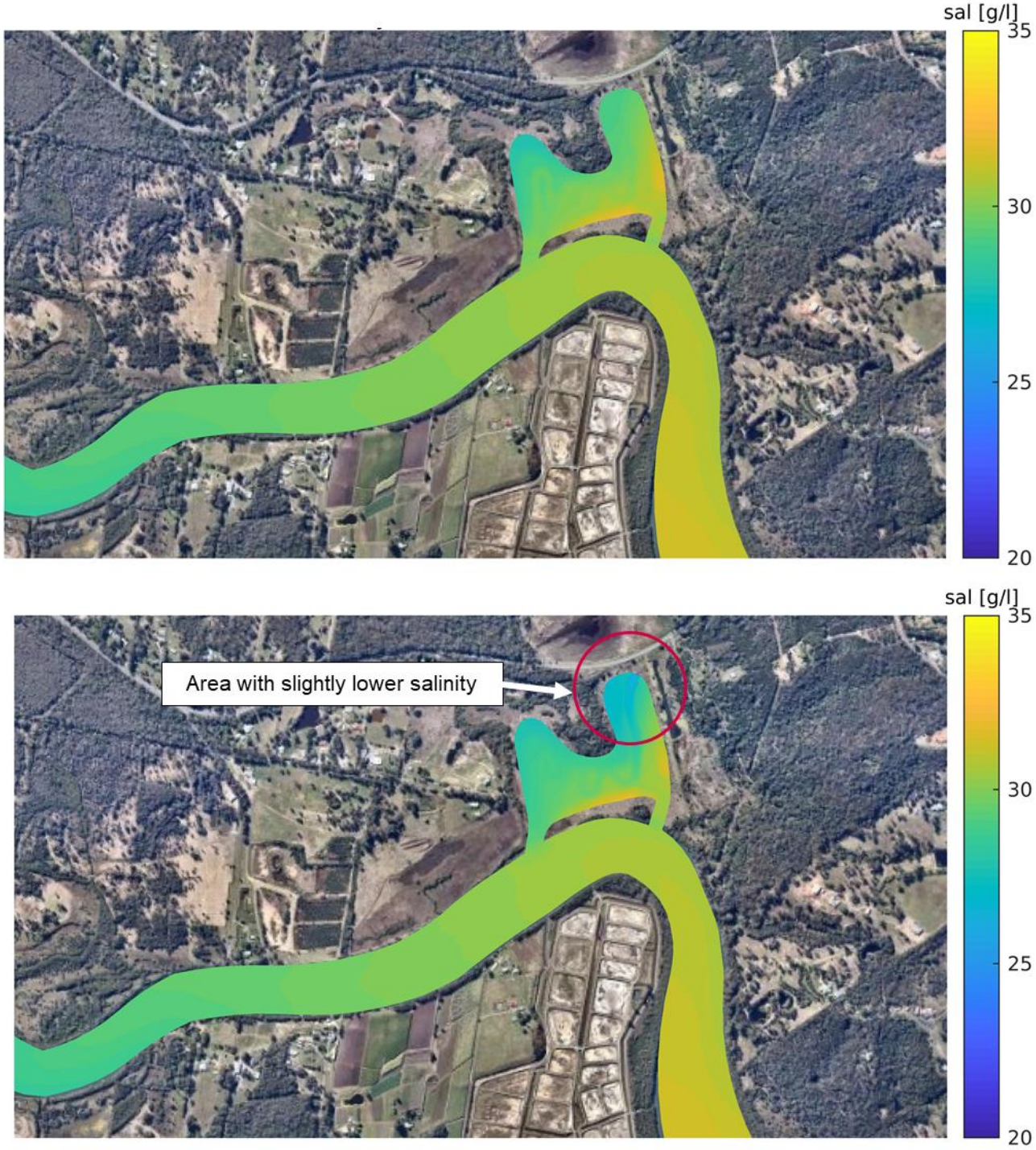


FIGURE 9-5 MEDIAN SALINITY DISTRIBUTION – ABOVE: BASE CASE (NO RECYCLED WATER DISCHARGE), BELOW: DEVELOPED CASE (WITH RECYCLED WATER DISCHARGE)

9.1.3 Nitrogen

The expected changes to Total Nitrogen (TN) within the Logan River Estuary in the vicinity of, and attributable to, the MOA are provided in Figure 9-6. It is evident that no significant change in TN is expected when contextualised within the variation experienced throughout the tidal cycle during a month of dry weather. The slight differences in the minimum TN between the existing and base cases is reflective of a subtle variation in

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

the flow structure in the vicinity of the confluence with Serpentine Creek. This difference is attributable to the additional flows required to fill and drain the MOA. The difference in the median concentration between the base and developed cases is similarly more reflective of minor changes in flow patterns than the net effect of the MOA and discharges from the WWTP.

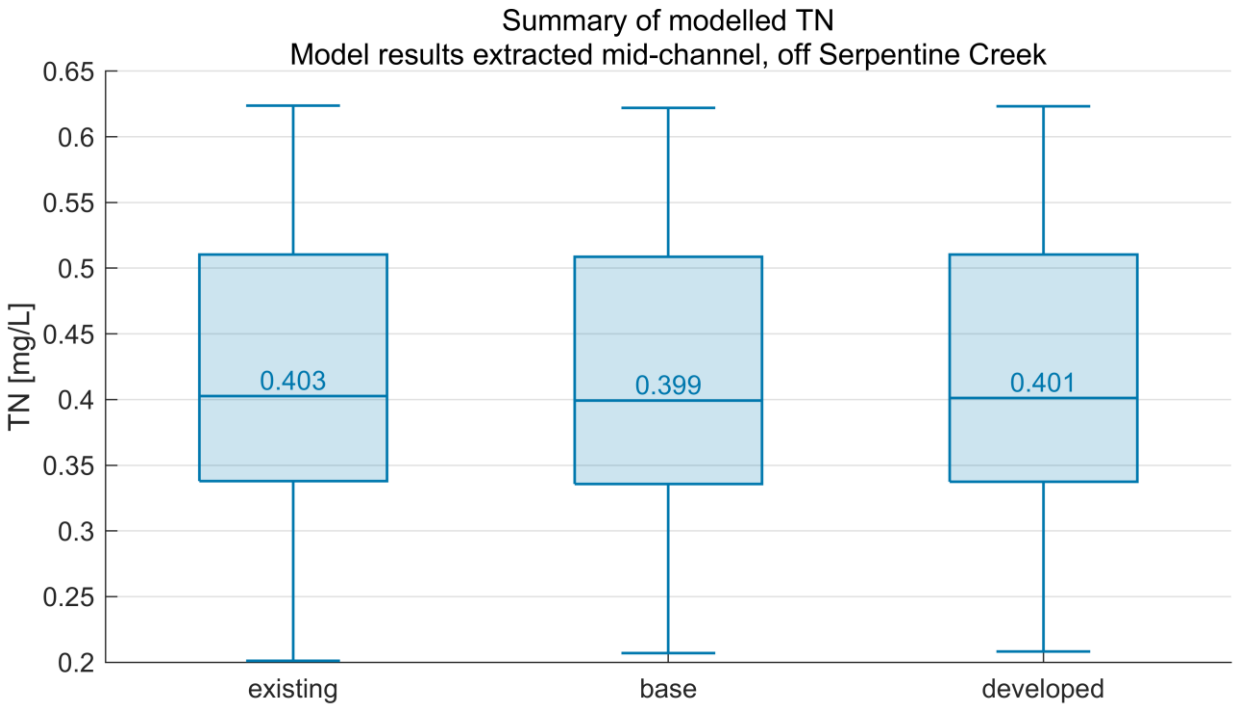


FIGURE 9-6 BOX PLOT OF MODELLED TOTAL NITROGEN

A comparison of the base case and developed case scenarios **within the MOA** showed that changes in water levels/volumes were influenced by the recycled water discharge in addition to tidal influence from the Logan River. As expected, the levels of TN **within the MOA** were also influenced by the recycled water discharge. Figure 9-7 shows the median distribution of TN for the base case and developed case scenarios. An apparent increase in the median TN concentration **within the MOA** at the recycled water discharge point north-east of the proposed mangrove site is seen. However, impacts in the Logan Estuary from TN in the recycled water discharge in the MOA are negligible and of no concern.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

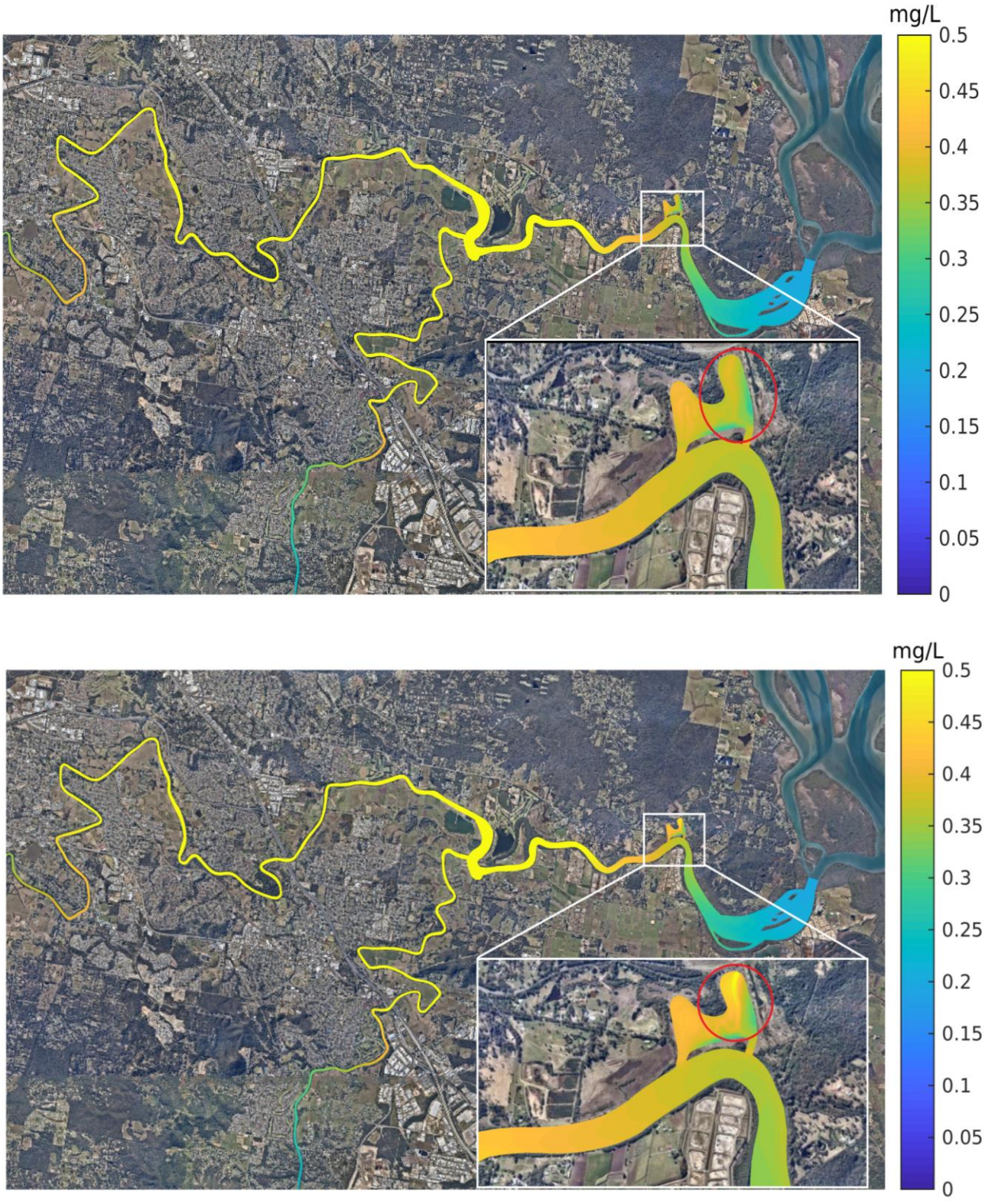


FIGURE 9-7 MEDIAN TOTAL NITROGEN DISTRIBUTION – ABOVE: BASE CASE WITH NO RECYCLED WATER DISCHARGE IN THE MOA; BELOW: DEVELOPED CASE WITH RECYCLED WATER DISCHARGE IN THE MOA

9.1.4 Phosphorus

The expected changes to the Total Phosphorus (TP) within the Logan River Estuary in the vicinity of, and attributable to, the MOA are provided in Figure 9-8. It is evident that the median TP decreases slightly from the existing case to the base case. Once discharges from the wastewater treatment plant are included however (developed case), the TP concentrations are again equivalent to those of the existing case. Therefore, the discharge had negligible impacts on the levels of TP in the Logan River.

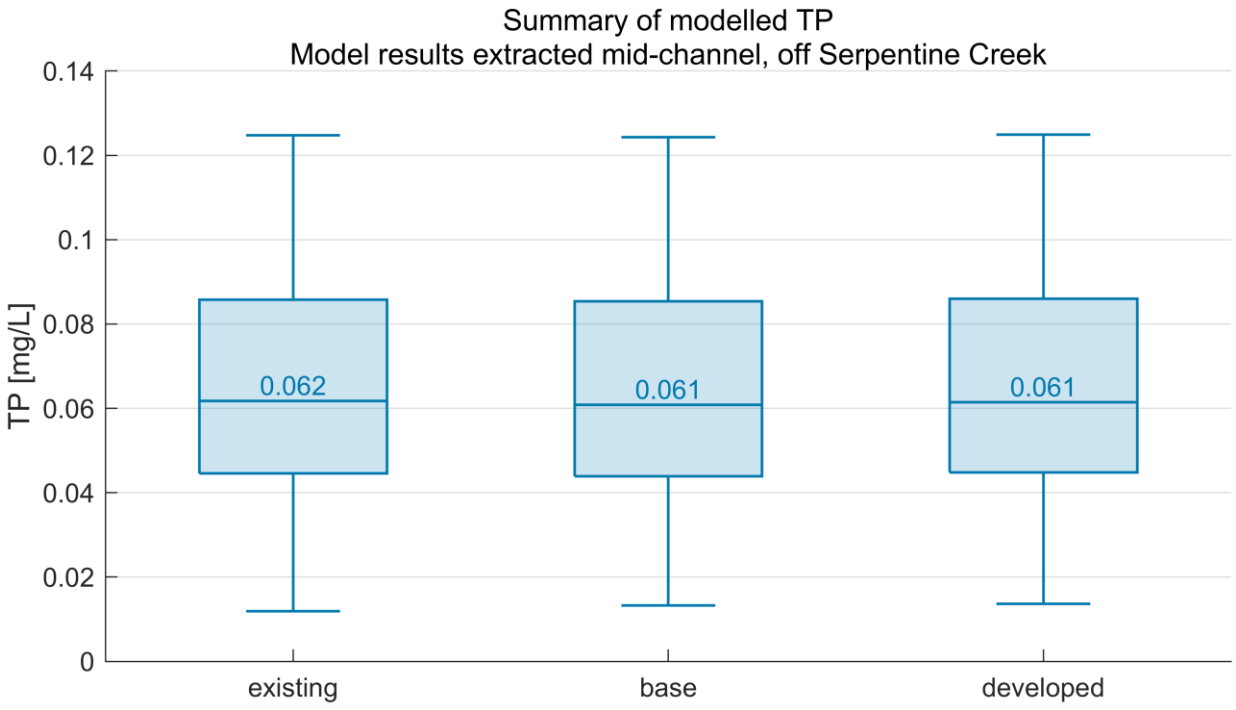


FIGURE 9-8 BOX PLOT OF MODELLED TOTAL PHOSPHORUS

9.1.5 Dissolved Oxygen

The expected changes to the Dissolved Oxygen (DO) within the Logan River Estuary in the vicinity of, and attributable to, the MOA are provided in Figure 9-9. It is evident that the median DO increases slightly from the existing case to the base case. Once the discharges from the wastewater treatment plant are included however (developed case), the DO concentrations are again equivalent to those of the existing case. Therefore, the discharge had negligible impacts on the levels of DO in the Logan River.

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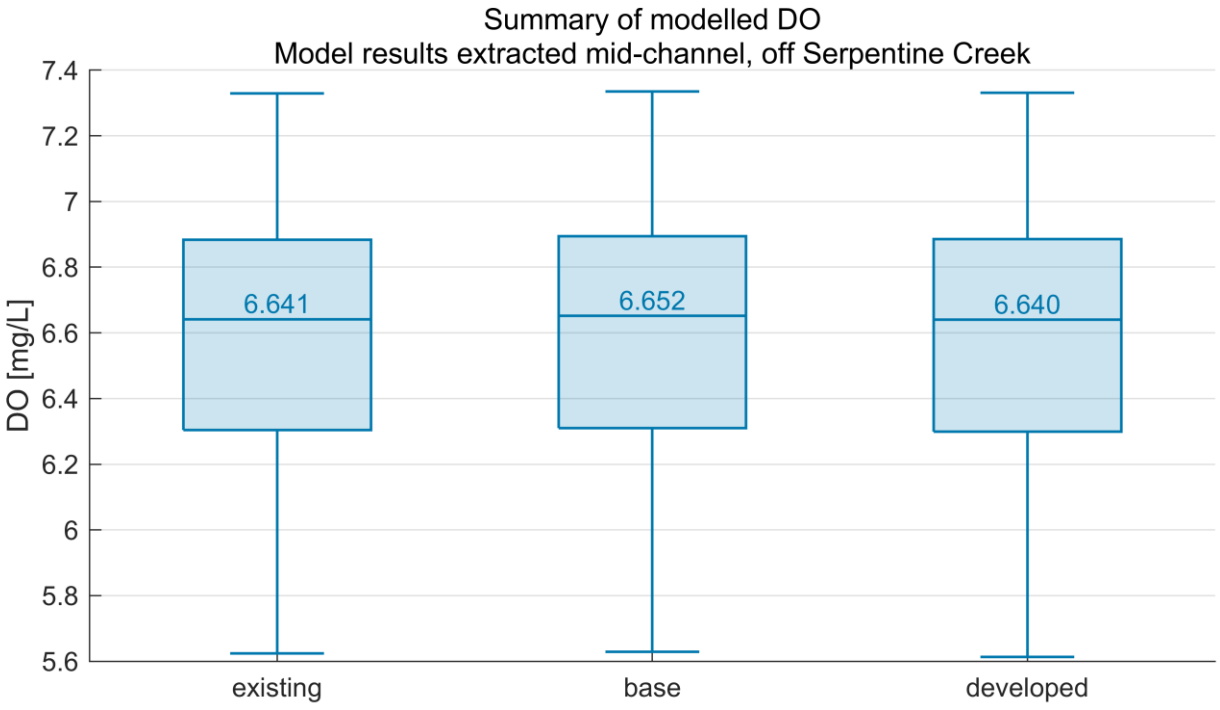


FIGURE 9-9 BOX PLOT OF MODELLED DISSOLVED OXYGEN

9.1.6 Others

The expected changes in speciated nutrient concentrations (Ammonia, Nitrous Oxide, Organic Nitrogen, Filterable Reactive Phosphorus and Orthophosphate), Turbidity, Chlorophyll-a and Temperature within the Logan River Estuary in the vicinity of, and attributable to, the MOA are provided in Figure 9-10 to Figure 9-17. It is evident that the changes in median values from existing to base case scenarios are miniscule for all parameters. Once the discharges from the wastewater treatment plant are included however (developed case), the concentrations still remain similar to those of the base and existing cases. Therefore, the discharge had negligible impacts on the levels of the modelled parameters in the Logan River.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

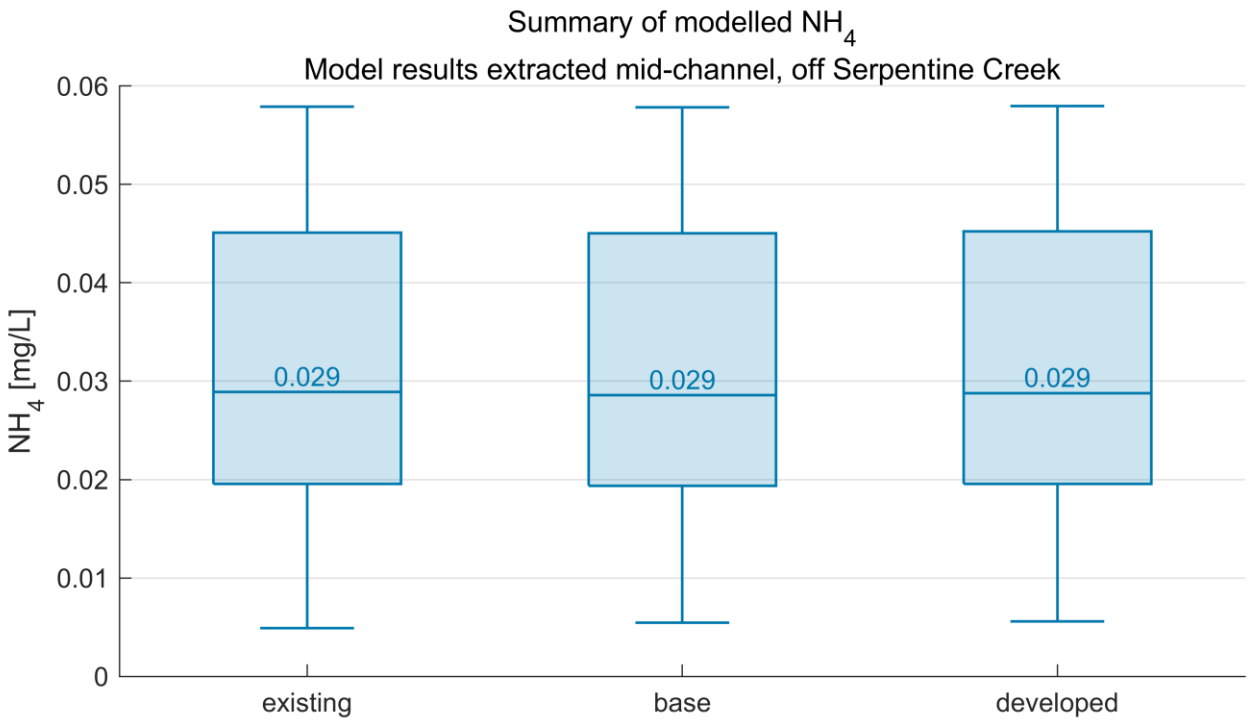


FIGURE 9-10 BOX PLOT OF MODELLED AMMONIA

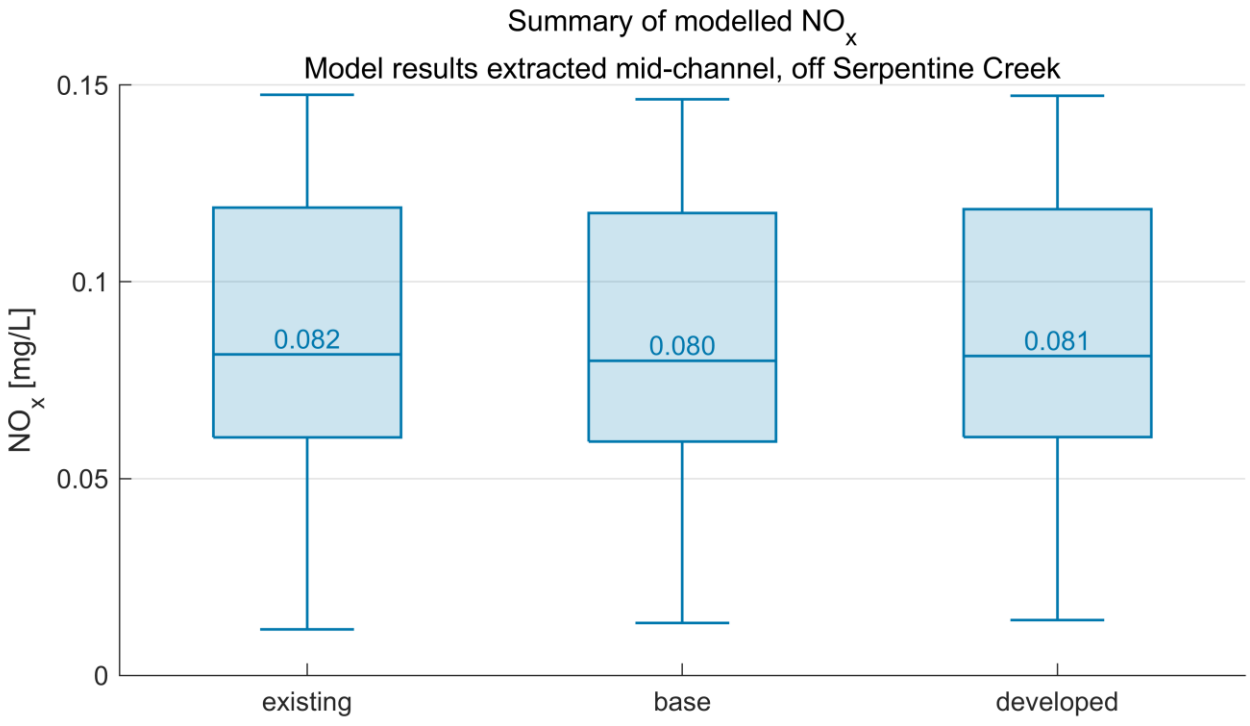


FIGURE 9-11 BOX PLOT OF MODELLED NITRATE AND NITRITE N (NOX)

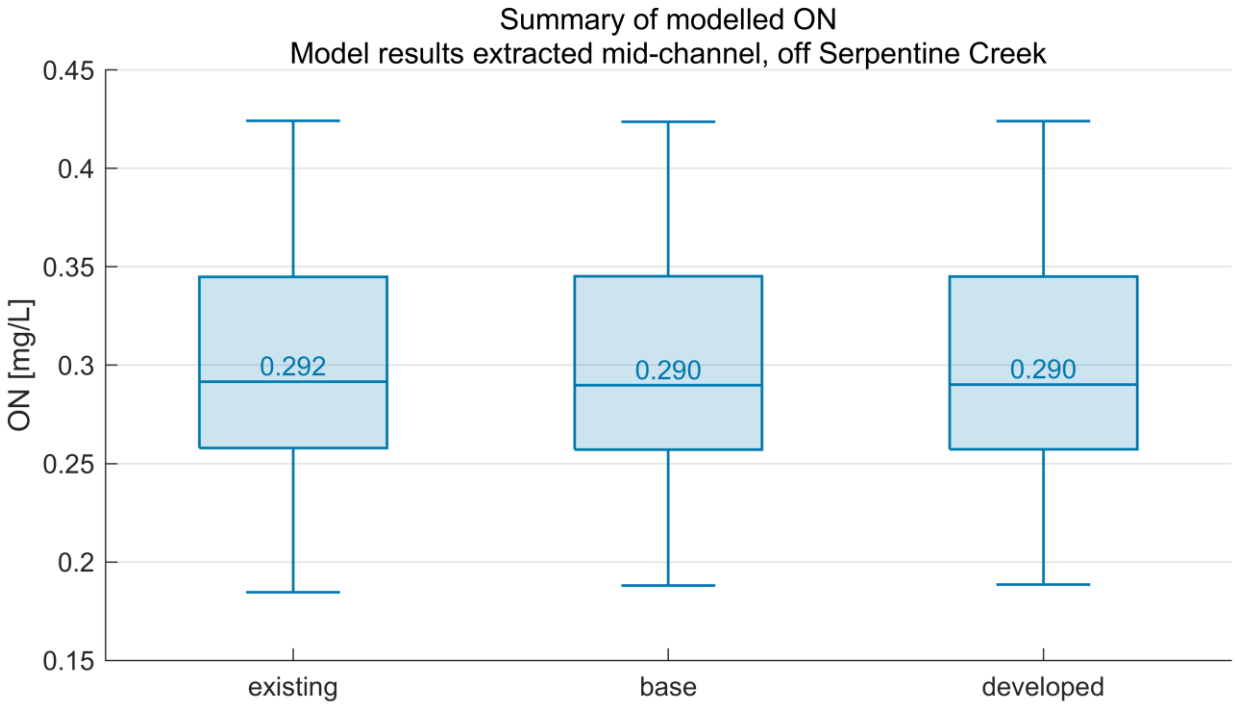


FIGURE 9-12 BOX PLOT OF MODELLED ORGANIC NITROGEN (ON)

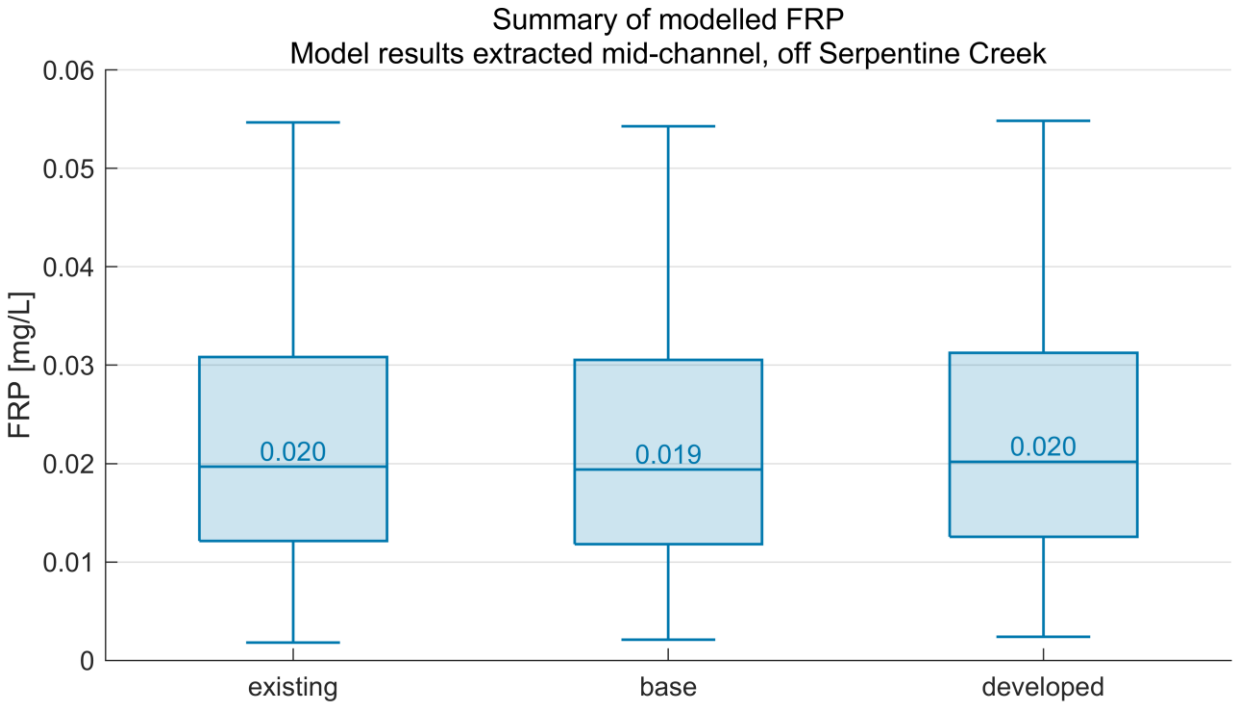


FIGURE 9-13 BOX PLOT OF MODELLED FILTERABLE REACTIVE PHOSPHORUS (FRP)

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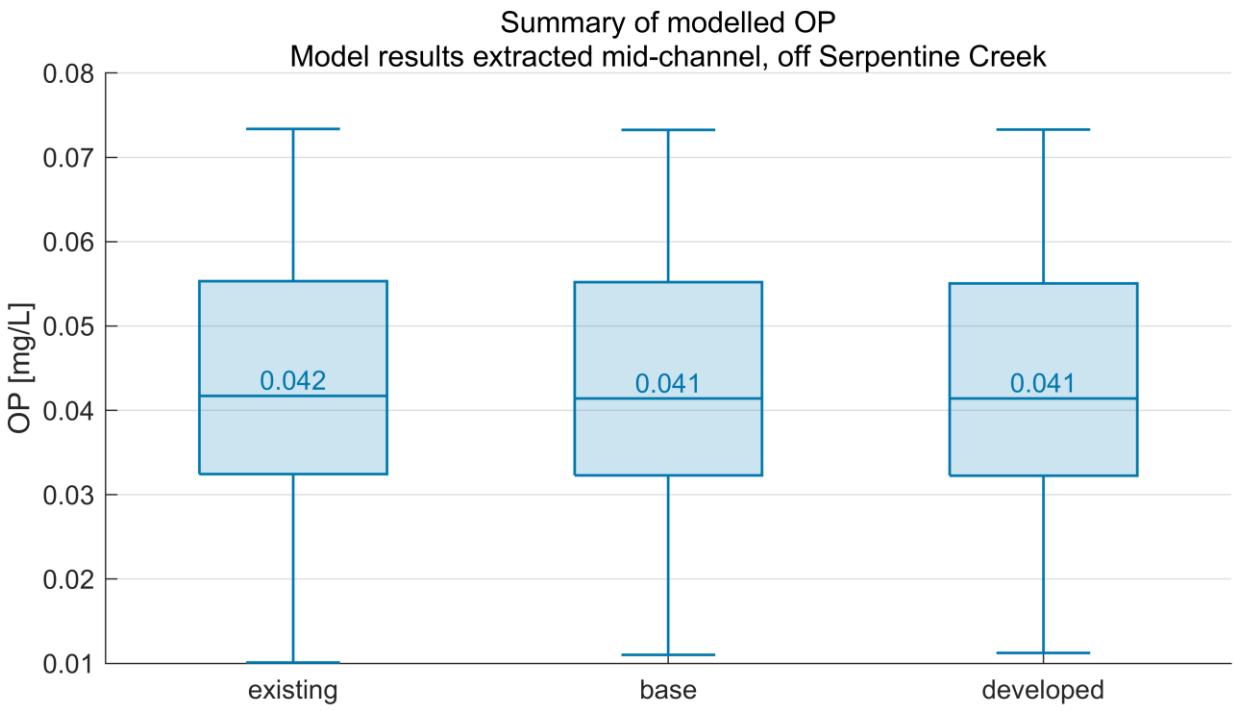


FIGURE 9-14 BOX PLOT OF MODELLED ORTHOPHOSPHATE (OP)

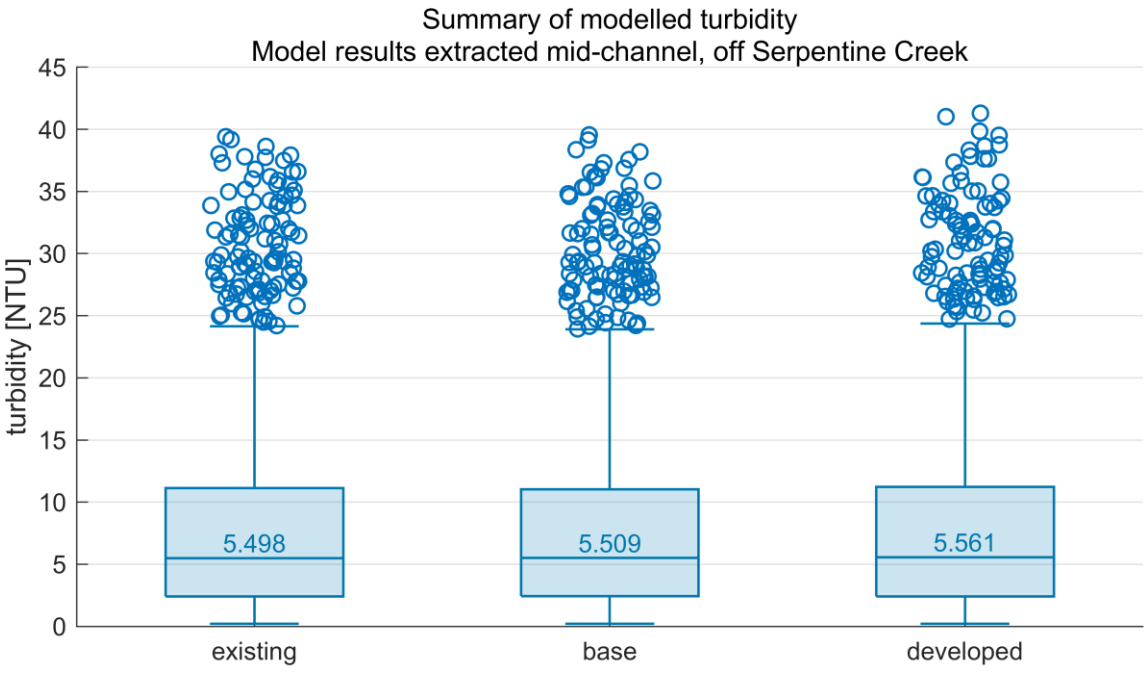


FIGURE 9-15 BOX PLOT OF MODELLED TURBIDITY[7]

[7] Values exceeding 1.5 times the interquartile range are plotted as circular markers

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

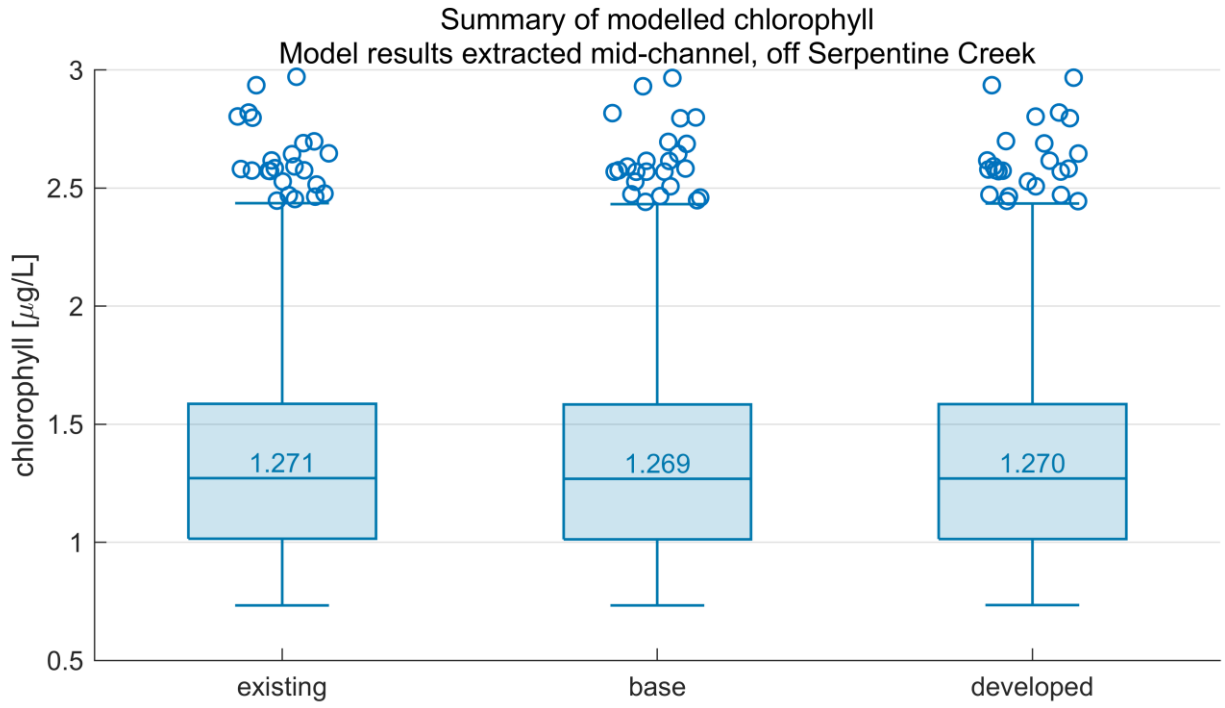


FIGURE 9-16 BOX PLOT OF MODELLED CHLOROPHYLL-A[1]

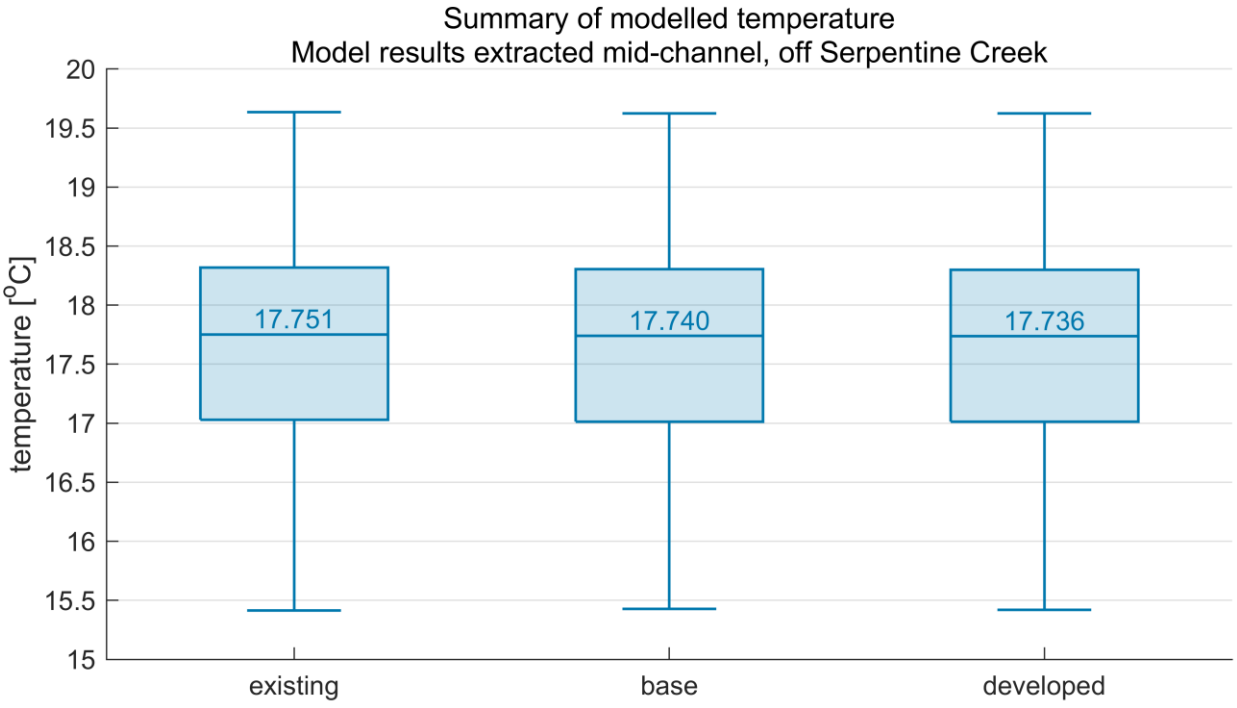


FIGURE 9-17 BOX PLOT OF MODELLED TEMPERATURE

9.1.7 Summary

Results from the modelling showed minimal impacts from the proposed recycled water discharge into the MOA. The effects of the modelled parameters on the Logan River Estuary are as follows:

- Recycled water discharge to the **MOA had negligible impacts on salinity levels** in the Logan River, which were shown to remain at ~ 30 g/L.
- An increase in the median TN concentration **within the MOA** at the recycled water discharge point north-east of the proposed mangrove site is seen. However, levels of Total Nitrogen (TN) within the Logan River Estuary in the vicinity of, and attributable to the MOA showed **negligible impacts** in the developed case. Slight differences in the minimum TN between the existing and base cases are reflective of a very subtle variation in the flow structure in the vicinity of the confluence with Serpentine Creek. This difference is attributable to the additional flows required to fill and drain the MOA.
- It is evident that the median TP decreases slightly from the existing case to the base case. Once the discharges from the wastewater treatment plant are included however (developed case), the TP concentrations are again equivalent to those of the existing case. Therefore, the discharge had **negligible impacts** on the levels of TP in the Logan River.
- The median DO increases slightly from the existing case to the base case. Once the discharges from the wastewater treatment plant are included however (developed case), the DO concentrations are again equivalent to those of the existing case. Therefore, the discharge had **negligible impacts** on the levels of DO in the Logan River.

9.2 Tidal Prism and Sediment Influx

The tidal prism is defined herewith as the volume of water that flows through a channel cross-section during the flood tide (low water slack to high water slack). As the volume of water which flows through the cross-section is dependent on the tidal range, the tidal prism is greater during spring tides than during neaps. Both the neap and spring tide values for the tidal prism are referred to in this report. The tidal prism is useful for identifying potential erosion issues associated with modifications to the estuary and contextualising freshwater inflows.

Furthermore, tidal prisms can be useful in determining the most suitable sizing of tidal inlets/outlets of the mangrove establishment, should the recommended conceptual design approach the design stage. In addition, the effects of modifications to the tidal prism (through sizing of the inlet) can be established to determine the amount of sediment deposited in and exported from the tidal inlet, which can in turn be the basis for the design of an appropriately sized sediment forebay during design stages in the future.

9.2.1 Effect on the Tidal Prism of the Logan Estuary

The tidal prism calculated 500 m downstream of the Southern Redland Bay WWTP was derived using the numerical model for both spring and neap tides for two scenarios, one for the existing case (undeveloped, no MOA) and one for the developed case (i.e. with the MOA and the recycled water discharge).

At the full operational capacity of the proposed Southern Redland Bay WWTP and upon the complete establishment of the mangrove/saltmarsh habitats, the change in the tidal prism in the Logan estuary (downstream of the Southern Redland Bay Mangrove site) was estimated to be between 0.6% (during neap tides) and 1.5% (during spring tides).

The changes in tidal prism are shown in Table 9-2.

TABLE 9-2 TIDAL PRISM CALCULATIONS

	Tidal prism (m^3) Without MOA	Tidal prism (m^3) With MOA	Percentage increase (%)
Spring tide	1.04×10^7	1.06×10^7	1.5%
Neap tide	0.540×10^7	0.543×10^7	0.6%

The changes in tidal prism are particularly small and will have no impact on bed and bank stability or coastal processes within adjacent sections of the Logan River.

In Figure 9-18, the flow of the incoming tide (at the inlet culvert) is represented in blue and the flow of the outgoing tide (ebb tide) is represented in green. Note that the outgoing tide from the MOA also includes the recycled water contributions (for a fully established development case) into the mangroves, which would consequently be discharged (during the ebb tide) into the Logan River. The estimated cumulative volume of water leaving the mangroves over a two-month period is also shown in Figure 9-18 (marked in yellow).

Based on the Southern Redland Bay WWTP Recycled Water Strategy (see Section 3.2), the estimated daily recycled water discharge (at full capacity) into the MOA was assumed to be at 200 L/EP/day or equivalent to 2.4 ML/day (2.4×10^3 m^3 per day). The volume of water which flows into the MOA through the inflow structure during a neap flood tide is 30×10^3 m^3. Similarly, for a spring tide, the volume of water which flows into the MOA is 150×10^3 m^3. Therefore, the recycled water discharge into the MOA will only account for 1.7% and 0.3% shift in volumes during neap and spring tides, respectively. These recycled water (freshwater) discharges will have a small effect on the salinity level in the mangroves (see Section 9.1.2). This change will not however impact the growth and propagation of the mangroves.

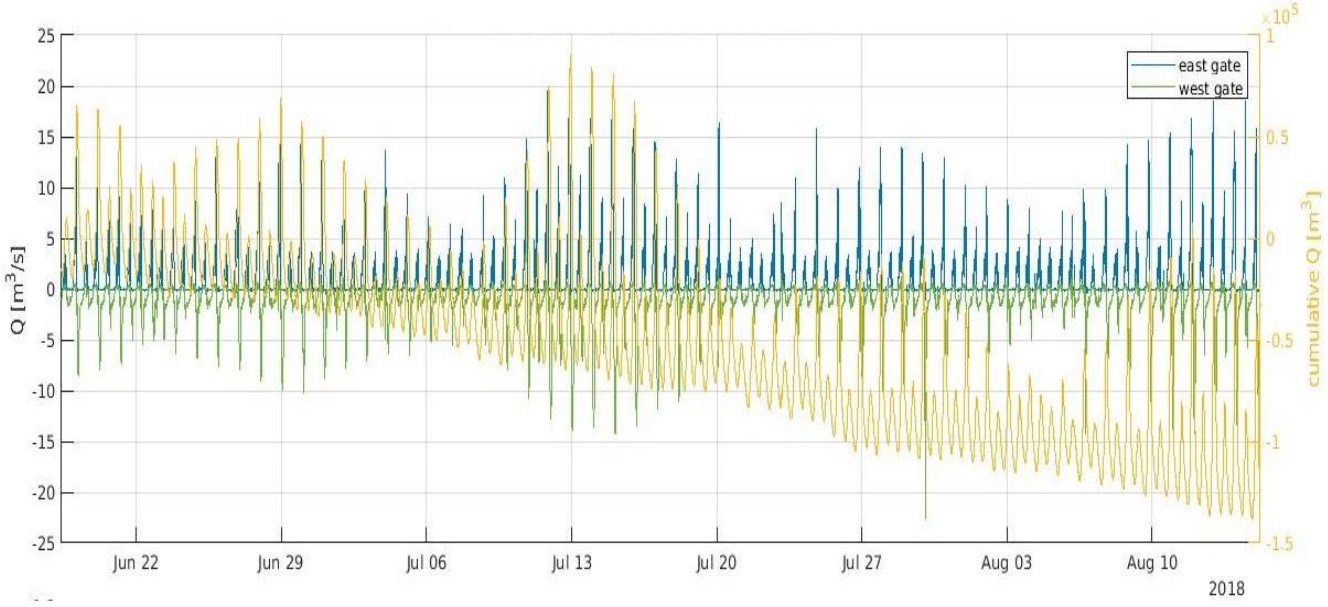


FIGURE 9-18 FLOWS (+VE INTO MANGROVE SITE) FOR THE PROPOSED MOA WITH WWTP RECYCLED WATER DISCHARGE (DEVELOPMENT CASE)

Recycled water flows to the MOA from the WWTP have been projected to grow linearly after an initial 5 to 6-year establishment period before they reach full capacity; this gradual change in the flows will provide:

- Ample time for mangrove establishment, with the initial stages of the development only servicing approximately 250 dwellings, hence no-low recycled water discharges during these initial stages; and,
- An increasing benefit to the environment by the time the mangroves are fully established (10-15 years).

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

9.2.2 Sediment Influx

A sediment forebay was incorporated in the model to:

- Regulate tidal inflows into the mangrove area at the inlet culvert; and
- Trap sediments by slowing down incoming tidal inflow and thereby facilitating the gravity separation of suspended solids.

Based on the sediment flux at the tidal inlet, the cumulative sediment flux (represented by the yellow line (Figure 9-19) into the mangroves was estimated.

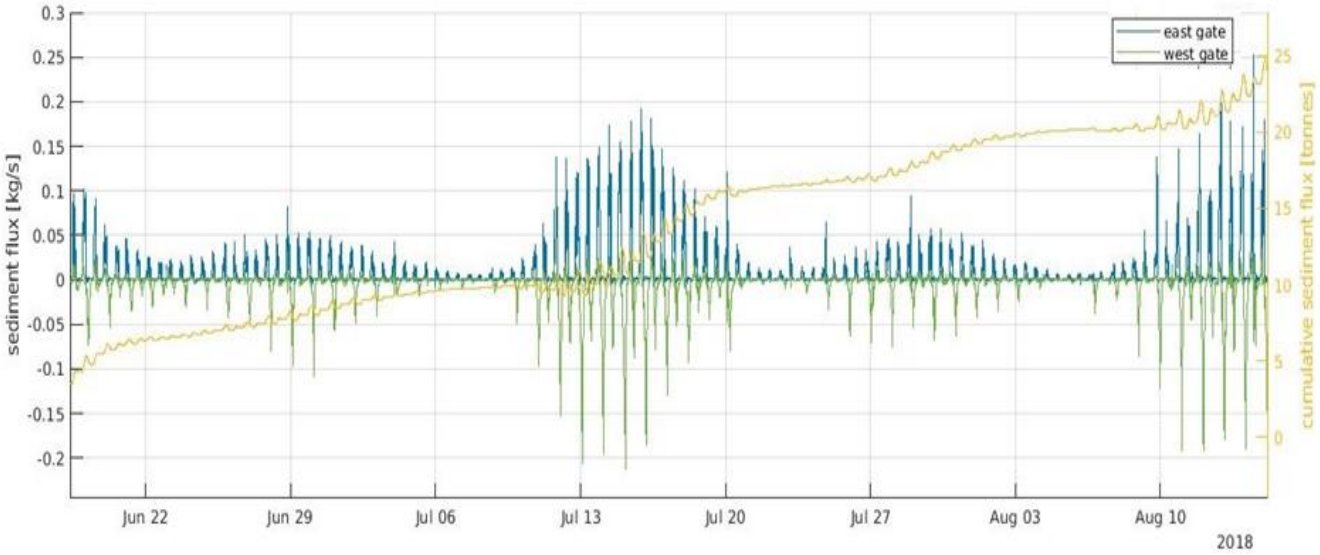


FIGURE 9-19 SEDIMENT FLUX IN THE PROPOSED SOUTHERN REDLAND BAY MANGROVES (DEVELOPMENT CASE)

The dry density of captured sediment (expected to be fine silt in this case) was estimated to be approximately 550 kg/m^3. This was used to estimate a minimum volume required to collect/trap sediment at the sediment forebay on an annual basis. It has been noted that although the presence of a forebay would be beneficial in maintenance of the inlet culvert structure, suspended sediments are also known to be important to mangrove health. Sediment influx into the MOA will not negatively impact mangrove growth and will in fact assist in very gradual soil accretion within the MOA which would assist in mangrove growth, mitigation of impacts from sea level rise and climate change. It is recommended that a sediment management plan be incorporated in the site-based management plan for the development to provide guidance on dredging frequencies.

9.2.3 Summary

- Recycled water discharge into the MOA will only account for 1.7% and 0.3% shift in volumes during neap and spring tides, respectively.
- The changes in tidal prism are particularly small and will have no impact on bed and bank stability or coastal processes within adjacent sections of the Logan River.
- Recycled water discharge in the MOA will have a small effect on the salinity level in the mangroves. This change will not impact the growth and propagation of the mangroves.
- Recycled water flows to the MOA from the adjacent WWTP have been projected to grow linearly after an initial 5 to 6-year establishment period before they reach full capacity; this gradual change in flows will provide ample time for mangrove establishment.

- Sediment influx into the MOA will not negatively impact mangrove growth.
- Gradual sediment accretion in the MOA will assist in mangrove growth, mitigation of impacts from sea level rise and climate change.

9.3 Waterborne Pathogens

9.3.1 Desktop Assessment

9.3.1.1 Overview

For Stage 2 assessments (see Section 1), Water Technology sought advice from CSIRO to provide a site-specific assessment of the risks associated with viruses that could be present in the recycled water discharge which may potentially pass through the different treatment processes and enter the Logan River. The main concerns that were addressed were:

- The risk from White Spot Syndrome Virus; and
- The likelihood of any risk from enteric (relating to or occurring in the human intestine) viruses.

9.3.1.2 White Spot Syndrome Virus

CSIRO indicated that despite the absence of any information (literature) on the presence of White Spot Syndrome Virus in sewage, any risk for the proposed project can be considered minimal. The report by CSIRO also advised that although there remains a possibility of infected imported prawns reaching supermarket shelves or an even smaller possibility of White Spot Disease still being present in crustaceans caught in South East Queensland waters, the virus cannot infect humans. Thus, if consumed, the virus can be expected to merely pass through the digestive system of a consumer and be excreted without increasing in number. Points to note from their assessment were:

- It was considered unlikely that any infectious White Spot Syndrome viral particles would be excreted in faeces as the human digestive system is an extremely hostile environment for microorganisms such as viruses;
- It was stipulated that any probable infectious White Spot Syndrome viral particles reaching the sewerage system would most likely come from the washing of plates, bowls and utensils that have come into contact with raw infected prawns;
- The potential chance or rate of incidence of washing contaminated utensils into the sewerage system was considered very low, thus the number of infectious White Spot Syndrome viral particles entering the sewage system should also be considered very low and would be diluted to insignificant numbers in the sewage;
- The detection of viruses in raw sewage (even if an attempt was made) was considered highly unlikely; and
- It was stipulated that even if White Spot Syndrome viral particles did enter the sewerage system, sewage being another harsh environment, there would be a strong potential for a virus such as the White Spot Syndrome Virus to be degraded in the raw sewage

In the unlikely scenario where a White Spot Syndrome viral particle was able to reach the proposed treatment system being considered in this study, due to its larger size and morphology, and the capacity of WWTP treatment facility (which in this case will be a Membrane Bioreactor system) and wetlands to reduce viral numbers by an expected minimum of 3[8] and 1 log removals respectively (4 log combined), it was considered

[8] Note that subsequent works in Section 9.3.3 have recommended disinfection of dry weather discharges from the WWTP which will provide even further buffering in this regard.

probable that any White Spot Syndrome Virus that could be present would be effectively removed by these treatment systems. Therefore, it was determined that the likelihood for crustaceans residing in the mangrove system to become infected from the White Spot Syndrome virus would most certainly be through contamination from the Logan River - and not from treated wastewater.

9.3.1.3 Human Enteric Viruses

Apart from the assessed risk from White Spot Syndrome virus, the presence of human enteric viruses in raw sewage was also identified as a potential risk as recycled water discharge from the WWTP is expected to contain a range or enteric viruses, all of which may pose a health risk to humans.

The assessment observed the following:

- With a potential minimum removal rate of 3 log by the proposed MBR and a further 1-2 log by the proposed wetlands, the reduction of viruses would align with what is generally observed in conventional treatment systems used in South East Queensland;
- If the MBR system were to achieve greater than 3 log removal, viral removal rates across the freshwater lagoon and subsequent mangrove system could be expected to achieve a high treatment efficiency; and
- If an additional treatment step such as chlorination or UV treatment were included towards the end of the MBR system, increased disinfection rates of viruses and other microbial pathogens can be achieved.

9.3.1.4 Virus Removal

The potential influence of mangroves on virus removal rates was not identified due to the limited information provided in available literature. However, the potential for the following processes was noted:

- **Adsorption** - It was considered possible that there could be some removal of viruses through adsorption to soil and organic matter within the mangroves, however this would need to be assessed further by experimentation; and
- **Dilution** - The potential for further dilution (of treated recycled water) was identified as a probable occurrence once the water reached the Logan River, further reducing risks from viruses.

While the removal rates in the Logan River were not known, it was acknowledged that viruses decay in natural aquatic systems over time. Although the viral decay in the Logan River was considered limited, it was expected that the dilution factor for the few viral particles reaching the river would significantly reduce any calculated health risks. Although validation of virus removal is typically not required for recycled water discharge, additional UV disinfection would eliminate any possible (although highly improbable) chance of viruses entering the Logan River via the MOA.

Further detailed assessments were conducted for Stage 3 reporting (this Report), wherein TUFLOW-FV modelling was used to inform a pathogen tracer study, which is discussed below.

9.3.2 Tracer Model Simulations

The Logan-Albert TUFLOW-FV model was used to inform a pathogen tracer study, with guidance from Assoc Prof Susan Petterson from Water and Health Pty Ltd and Assoc Prof Anne Roiko of Griffith University, respective experts in the field of microbial risk assessments. The modelling results were reviewed by Assoc Profs Petterson and Roiko, who provided an assessment of the potential risk from enteric pathogens from the proposed recycled water discharge. The outcomes of this assessment are discussed below.

The simulations were run for both dry and wet weather events for the year 2019. For both cases, the following pathogen decay rates were used.

- Bacteria 0.461/day (natural log scale) 0.200/day (log10 scale)

- Viruses 0.058/day (natural log scale) 0.025/day (log10 scale)
- Cryptosporidium 0.071/day (natural log scale) 0.031/day (log10 scale)

Dry weather flowrates from the STP were set at 0.031 m^3/s, which is the average dry weather flow (ADWF).

For a defined extreme wet weather case separately modelled by Stantec, recycled water flowrates illustrated in Figure 9-20 were adopted.

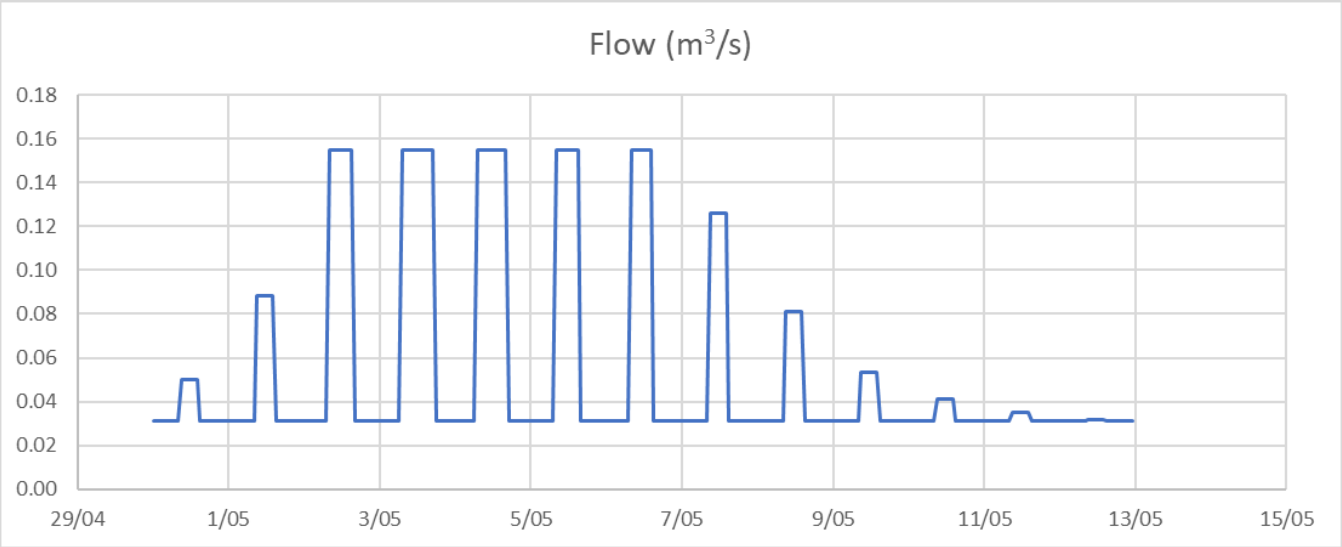


FIGURE 9-20 TYPICAL WET WEATHER FLOW RATES

The following considerations were applied for the wet weather case:

- The flowrates were appended to the results of the approximate two (2) months dry weather simulation when the system had reached quasi steady state conditions in terms of pathogen concentrations in the river.
- All flows up to 3 ADWF were initially assumed to be treated (but not disinfected), all flows between 3 and 5 times ADWF were assumed to bypass the WWTP and be untreated. No additional catchment flow in the river was assumed.
- All bacteria, viruses and cryptosporidium concentrations in the discharge under dry weather conditions were assumed to be 1 unit/volume. Up to 3 ADWF, this concentration dilutes to achieve the same load (i.e. at 3 ADWF the concentration is 0.33 unit/volume). Additional flows above 3 ADWF were increased in concentration at the following bypass concentration/treated ADWF concentrations as provided to Water Technology by Assoc Profs Petterson and Roiko:
  - Bacteria 1400/0.7 = 2000 (note units are microorganisms/L)
  - Viruses 1600/252.98 = 6.324 (note units are viruses/L)
  - Cryptosporidium 400/0.2 = 2000 (note units are oocysts/L)

Given the above considerations, the model results were used to derive the predicted changes in bacteria, viruses and cryptosporidium concentrations above background concentrations at two potential prawn farm intake points (chosen as they are likely to be the most sensitive receptors in the immediate area) located adjacent to the southern bank of the estuary in the Logan River, in proximity to the Site (see Figure 9-21). The model outcomes are shown in Figure 9-22 to Figure 9-24.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments



FIGURE 9-21 PRAWN FARM INTAKE POINTS

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

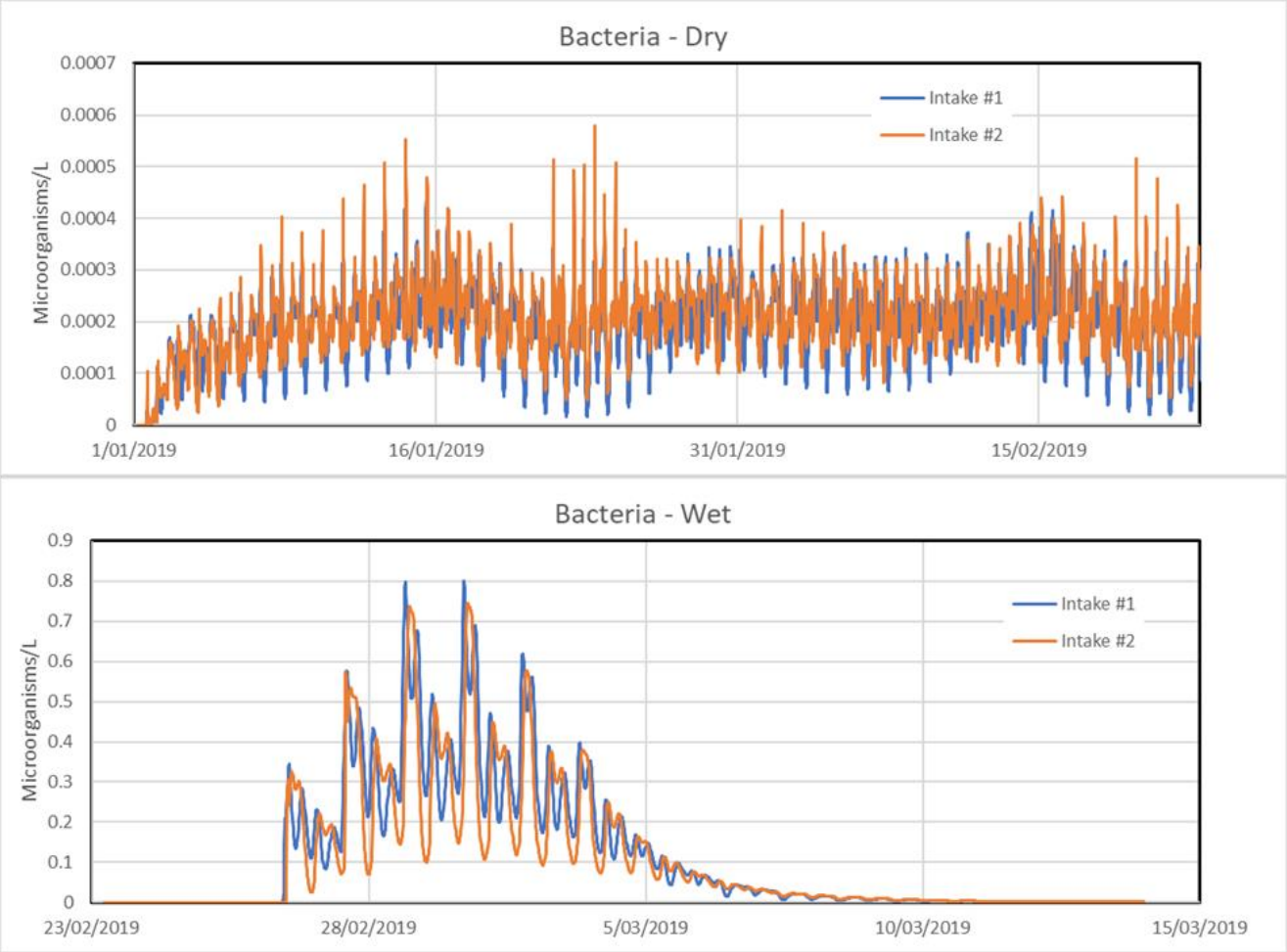


FIGURE 9-22 BACTERIA CONCENTRATION RESULTS

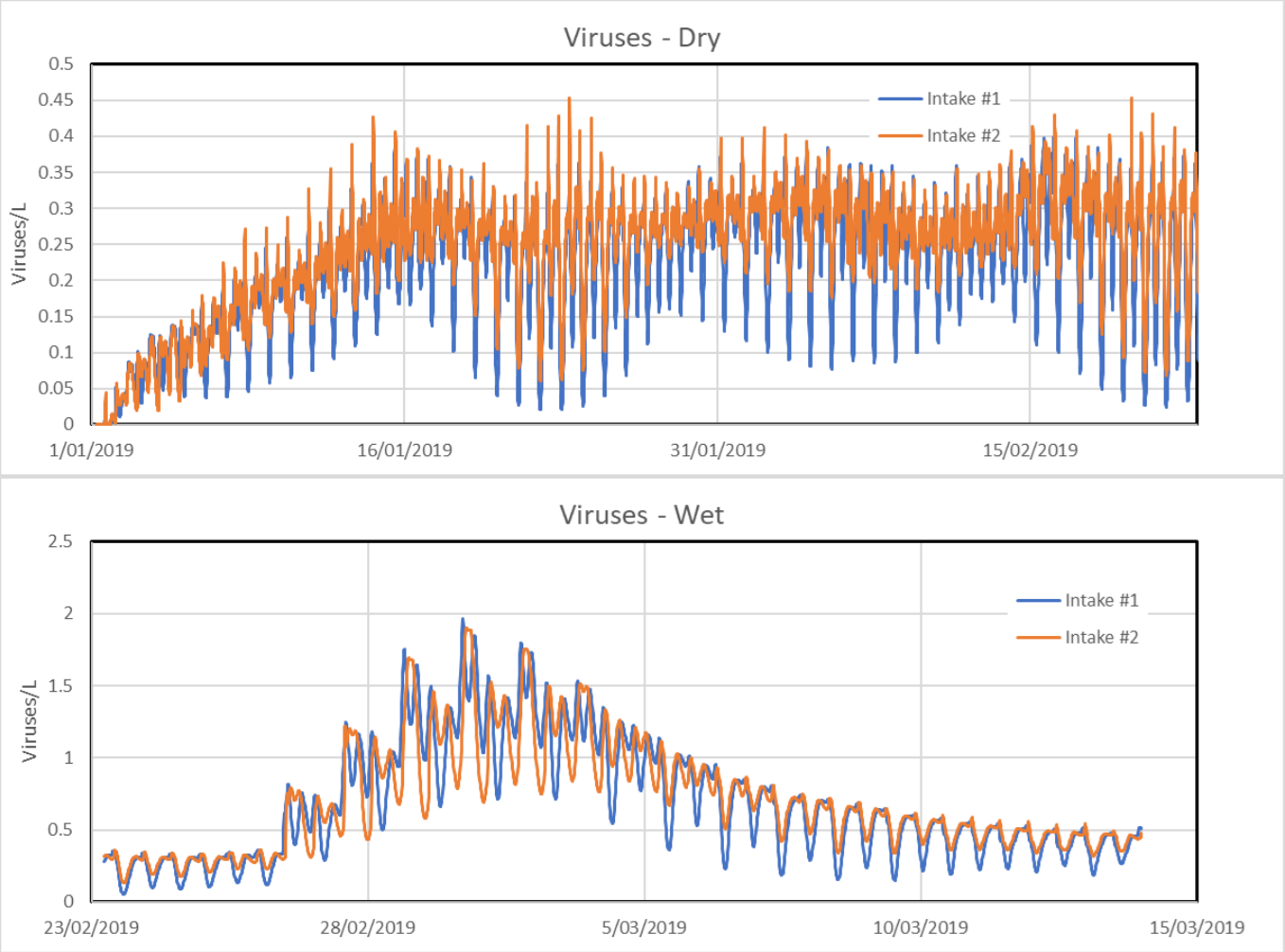


FIGURE 9-23 VIRUS CONCENTRATION RESULTS

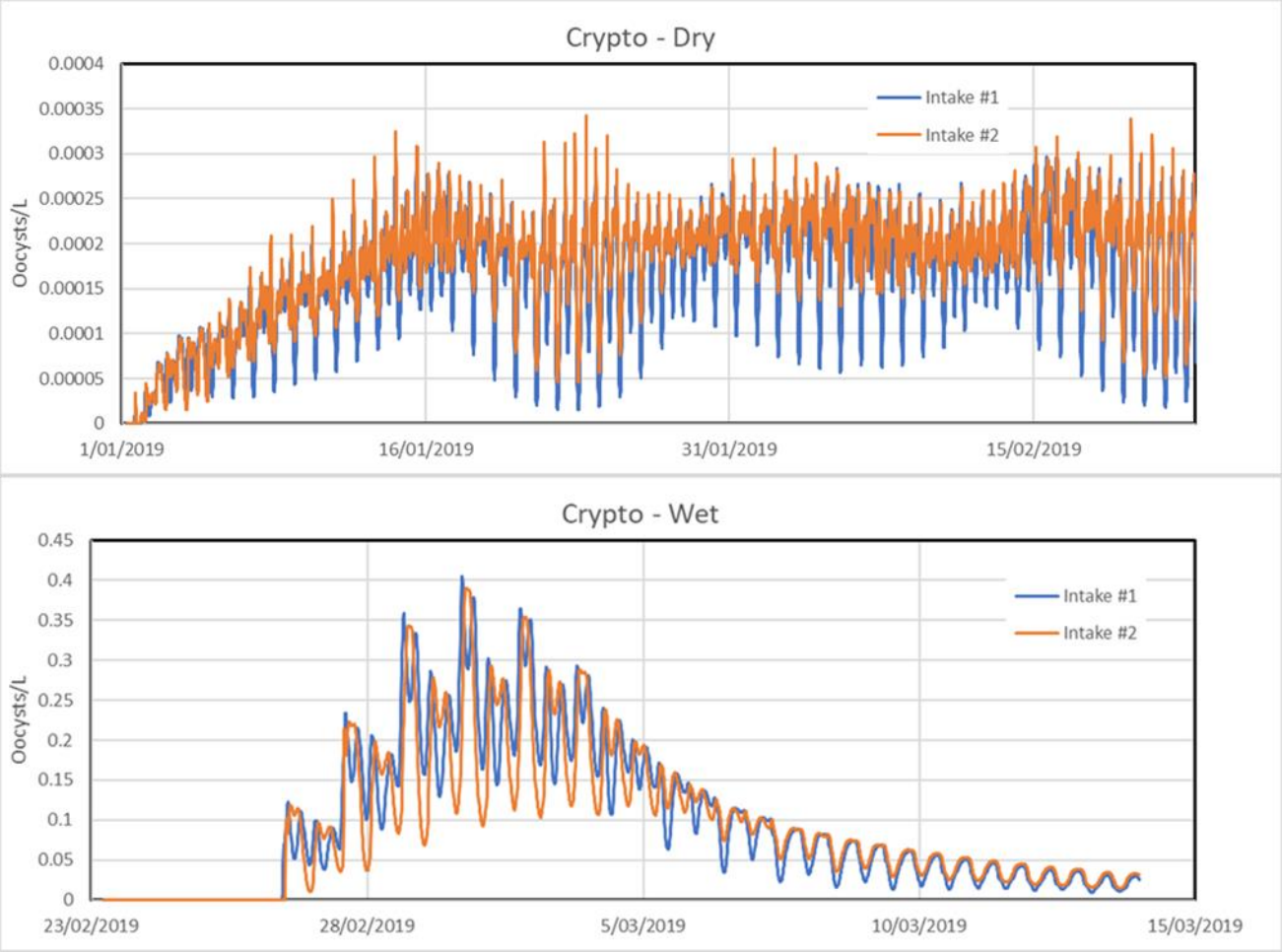


FIGURE 9-24 CRYPTOSPORIDIUM CONCENTRATION RESULTS

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

Comparisons of the predicted dry weather concentrations in the estuary against the treated ADWF concentrations (bacteria 0.7 microorganisms/L, viruses 252.98 viruses/L, crypto 2 oocysts/L) to estimate log reduction values are shown in Figure 9-25.

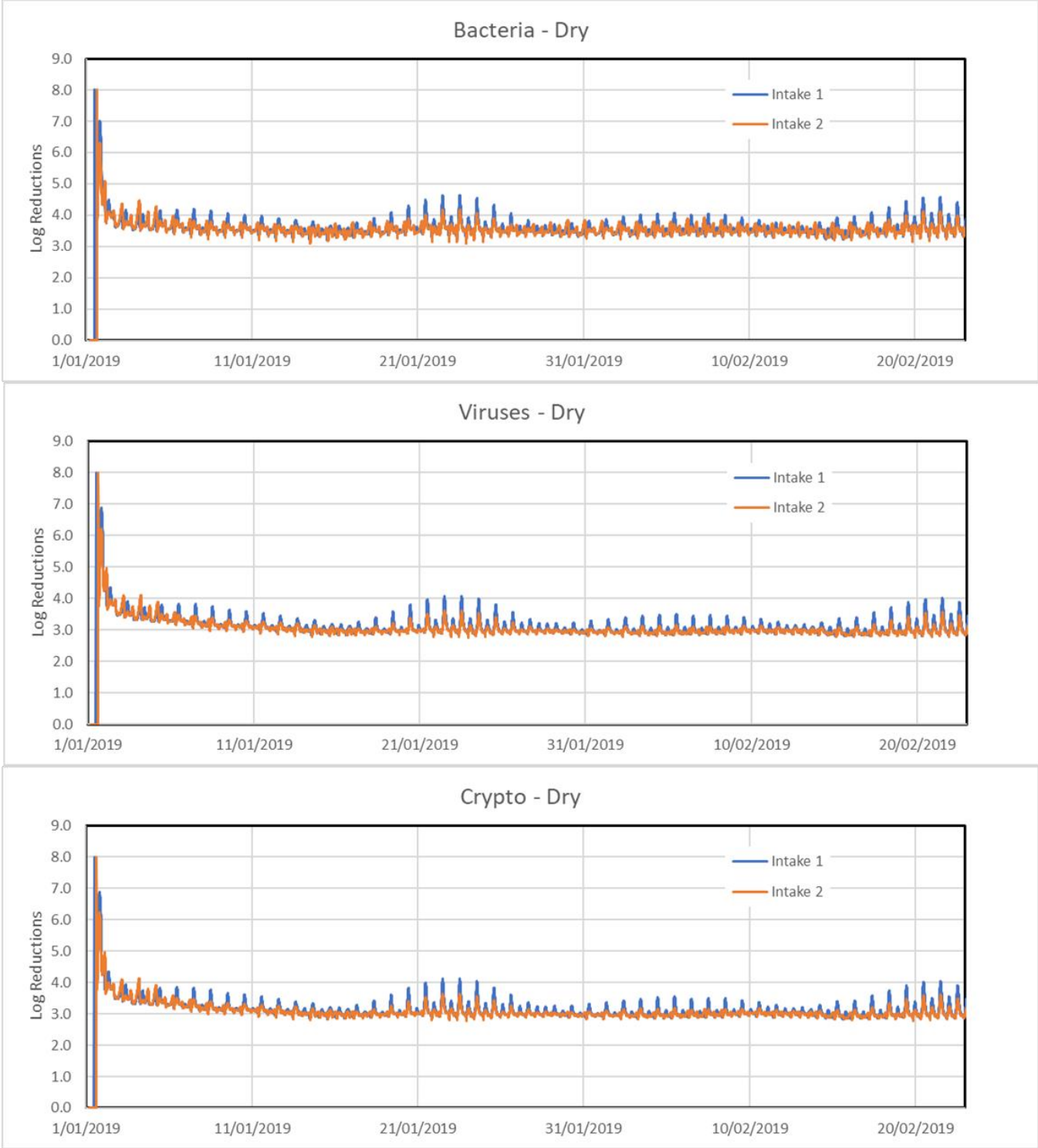


FIGURE 9-25 DRY WEATHER LOG REDUCTIONS

Comparisons of the predicted wet weather concentrations in the estuary against the flow weighted average concentrations discharged (bacteria 86.6 microorganisms/L, viruses 301 viruses/L, crypto 24.7 oocysts/L) to estimate log reduction values under wet weather conditions are shown in Figure 9-26

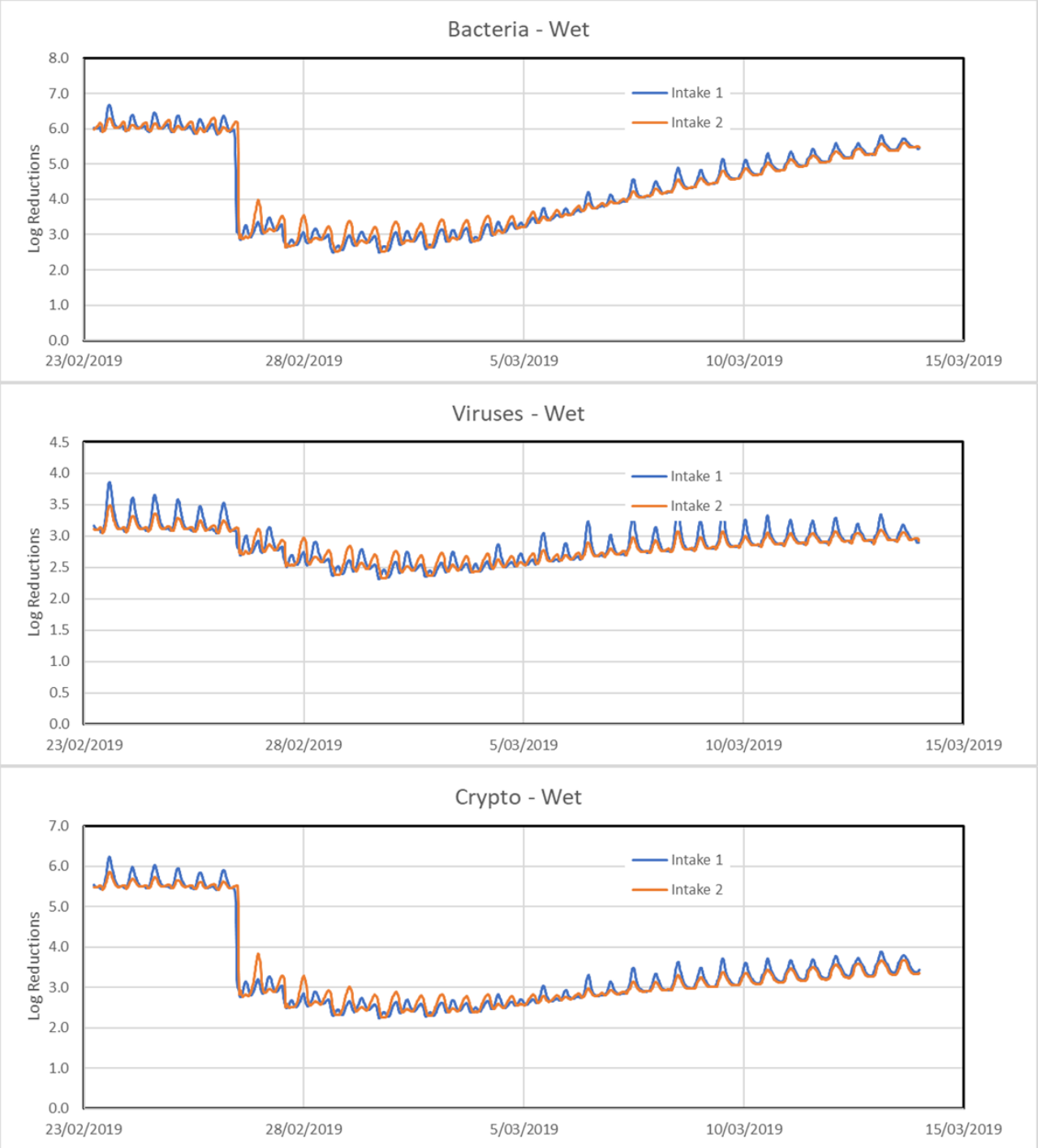


FIGURE 9-26 WET WEATHER LOG REDUCTIONS

Model results can be interpreted as follows:

- Under DWF conditions:
  - Bacterial concentrations of around **0.00025 microorganisms/L** (and a median log reduction of **3.52**).
  - Virus concentrations of around **0.3 viruses/L** are predicted (and a median log reduction of **3.01**).
  - Crypto concentrations of around **0.00025 oocysts/L** are predicted (and a median log reduction of **3.04**).
- Under WWF conditions:
  - Bacterial concentrations of around **0.7 microorganisms/L** are predicted (and a median log reduction of **4.18**).
  - Virus concentrations of around **2 viruses/L** are predicted (and a median log reduction of **2.84**).
  - Crypto concentrations of around **0.4 oocysts/L** are predicted (and a median log reduction of **3.03**).

The results were provided to Assoc Profs Petterson and Roiko for a pathogen risk assessment, which is presented below.

9.3.3 Pathogen Risk Assessment

9.3.3.1 Assessing Risk from Enteric Pathogens

When human enteric pathogens are released into natural waterways, they only pose a risk to human health if people are exposed and subsequently ingest the pathogen. Ingestion (or in some cases inhalation) is necessary for infections to occur. Users of river water may ingest water through the mouth when swimming, or in smaller quantities through splashing, hand to mouth transmission (hands become wet and then the person touches their mouth with their fingers) or aerosols (breathed in through the nose, but subsequently swallowed with nasal secretions to the gastroenteric system). The amount of water consumed in each of these cases is different, and the risk of infection is related to both the concentration of pathogens in the water, and the volume of water ingested.

To date, with respect to enteric pathogen safety, there are no guidelines defining the adequate treatment and safe release of treated sewage to natural waterways in Australia. In the absence of specific guidance, the Australian Guidelines for Water Recycling (AGWR) provide a framework to assess the adequacy of treatment at the proposed Southern Redland Bay WWTP. There are some limitations with applying this approach, which are discussed later.

The approach for defining treatment requirements (Log10 reductions) in the AGWR (NRMMC and EPHC 2006) is illustrated in Figure 9-27. Based on the quality of the source water (in this case raw sewage) and the estimated exposure (ingestion) resulting from end-use practises, the recommended Log10 reductions are defined in order to achieve a safety target (quantified in Disability Adjusted Life Years, or DALYs).

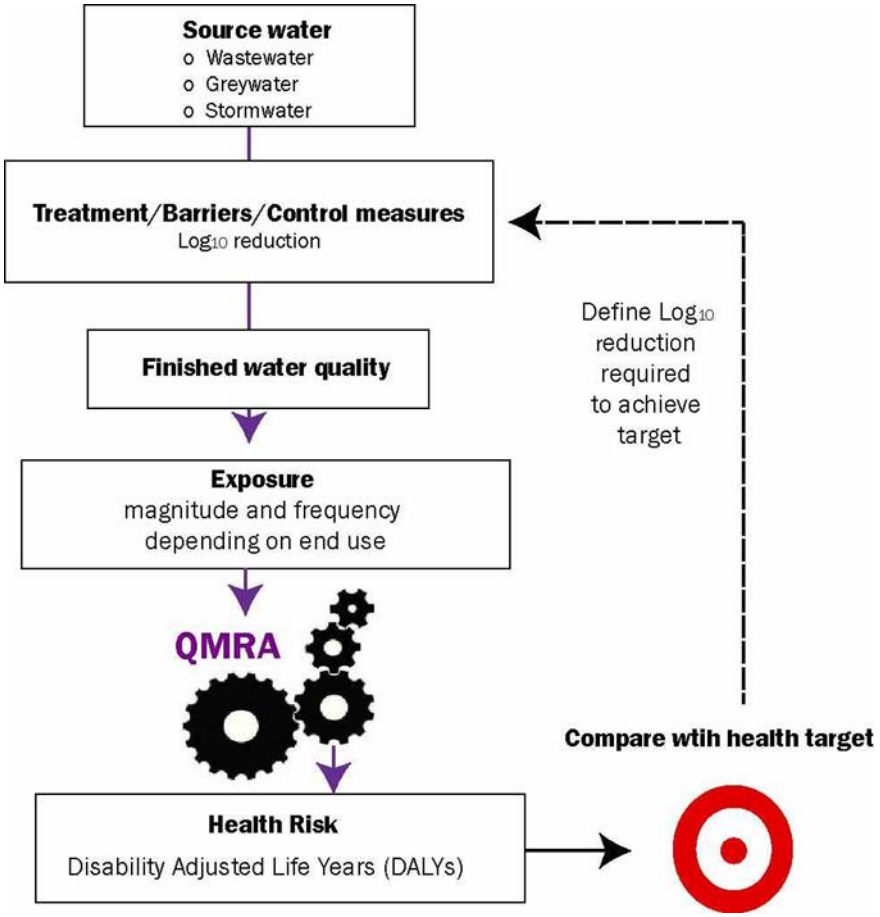


FIGURE 9-27 APPROACH FOR DEFINING TREATMENT REQUIREMENTS IN THE AUSTRALIAN GUIDELINES FOR WATER RECYCLING (CUNLIFFE AND PETTERSON 2019)

The advantage of this approach is that it allows for the design and management of treatment that is 'fit-for-purpose'. In addition, environmental barriers can be assessed, performance quantified and then included in the overall treatment train contributing the total Log10 reduction required to achieve safety.

9.3.3.2 Assessing Overall Treatment Performance

For the Southern Redland Bay WWTP, the proposed MOA together with the adjoining section of the Logan River was assessed as an enteric pathogen barrier for the protection of recreational and other water users in and around adjacent sections of the lower Logan estuary.

The modelling of reference pathogens from the proposed WWTP release adopted two potentially sensitive reporting locations on the Logan River adjacent to the southern bank of the estuary (Site 1 and Site 2) (see Section 9.3.2). Results at these sites were used to quantify the Log10 reduction achieved by dilution and natural decay processes in the proposed MOA and adjoining section of the Logan River for each of three reference pathogens: Bacteria (hybrid of E. coli and Campylobacter), Virus (hybrid of adenovirus and norovirus) and Cryptosporidium.

The design Log10 reductions for the membrane bioreactor plant, together with the average dry weather flow (ADWF) Log10 reductions for the MOA are included in Table 9-3.

TABLE 9-3 DESIGN AND MODELLED LOG10 REDUCTIONS FOR TREATMENT BARRIERS/CONTROLS AT SOUTHERN REDLAND BAY UNDER DRY WEATHER CONDITIONS.

	Log10 reduction		
	Bacteria	Virus	Cryptosporidium
Membrane bioreactor	4	1.5	4
MOA and Logan River	3	2.8	2.8
Total	7	4.3	6.8

9.3.3.3 Adequacy of treatment and controls

In order to assess the adequacy of treatment, end-use activities need to be defined. In the case of the Logan River, a wide variety of uses may occur including recreational and occupational (e.g. aquaculture) activities. Rather than attempt to define these, the AGWR approach was applied to quantify the maximum allowable safe volume that could be consumed (given the level of protection in Table 9-3) for each reference pathogen. Figure 9-28 illustrates the relationship between volume consumed and required Log reduction for each reference pathogen. The more specific calculations are included in Table 9-4.

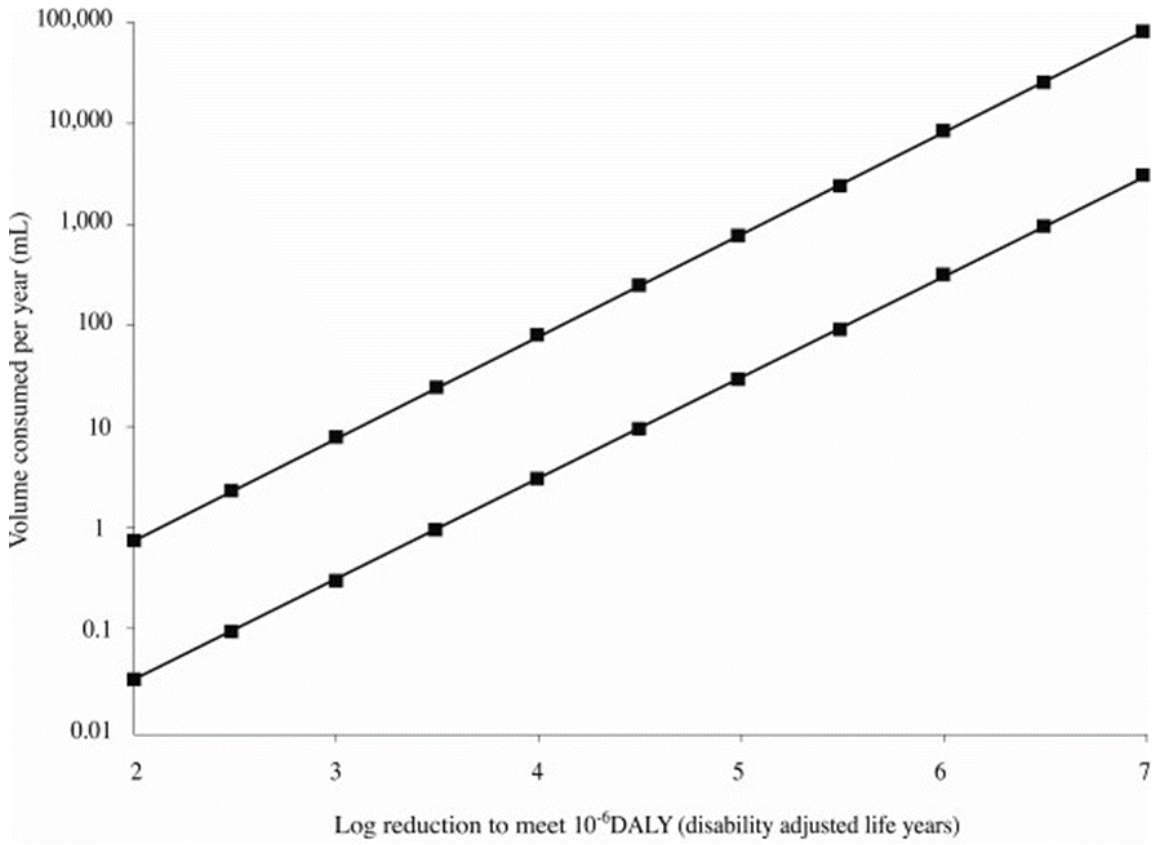


FIGURE 9-28 LOG10 REDUCTIONS REQUIRED AS A FUNCTION OF VOLUMES EXPOSED (REPRODUCED FROM AGWR FIGURE A2.1). UPPER LINE REPRESENTS BACTERIA AND PROTOZOA, LOWER LINE IS FOR VIRUSES

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

TABLE 9-4 CRITICAL CONSUMPTION VOLUMES TO MAINTAIN TOLERABLE RISK WITH EXISTING CONTROL MEASURES

	Bacteria	Virus	Cryptosporidium
Concentration in sewage (microorganisms/L)	7,000	8,000	2,000
DALY (d)	3.8×10^{-2}	2.5×10^{-3}	1.6×10^{-2}
Log10 reduction	7	4.3	6.8
Calculated maximum allowable consumption per year (mL) to achieve risk target[1]	54,000	6.2	51,000
[1] See AGWR for more details on how these calculations are undertaken			

While all end-use activities are not well defined, the results in Table 9-4 are informative. For bacteria and Cryptosporidium, water users would struggle to consume 54 and 51 L of river water per annum, and hence the level of proposed treatment is considered adequate. However, for viruses, the tolerable target of 6.2mL per annum could be easily exceeded by a broad range of end users and hence further treatment is recommended to protect water users from enteric viruses. ***Adding disinfection to provide a further 3 Log10 barrier for viruses would increase this tolerable consumption volume to 6.2 L per year and provide a much greater margin of safety.***

9.3.3.4 Background Contamination in the Logan River

The risk assessment in Table 9-4 provides only a partial picture of the water user risks for the Logan River, as the ***background*** level of contamination from the upstream catchment and other point sources to the estuary has not been considered. Only the recycled water discharge from the SRBWWTP has been modelled, and the background concentration of pathogens has been assumed to be zero. This is a limitation of using the recycled water framework for an environmental release context. The concentration of reference pathogens in the Logan River has not been assessed as part of this investigation and is therefore considered to be unknown.

It could be argued that while the SRBWWTP releases may be managed for safety on their own, in combination with the background contamination in the Logan River the risk to water users may be unacceptable. Microbial risks do not, however, sum on a linear scale, but rather on a Log10 scale. Therefore, as long as the proposed WWTP release is managed below the target risk level, it will not significantly increase the risks to water users from background conditions. This is illustrated in Figure 9-29. Since the level of contamination in the Logan River is unknown, for the purpose of illustration five different scenarios were quantified with a background concentration of 100, 10, 1, 0.1 and 0.01 viruses per L respectively. The risk scenarios were modelled with the recycled water discharge from the WWTP achieving the safety target of 10^{-6} DALYs.

The risk from the background contamination and the total risk to water users were quantified.

With a high background concentration of viruses in the Logan River, the total DALYs exceed the safety target (100, 10 and 1 viruses per L), however in each of these cases the contribution from background contamination was driving the risk. That is, in Figure 9-29, the background contribution in these cases is equivalent to the total DALYs. Once the background contribution drops below the SRBWWTP contribution (0.1 and 0.01 virus unit/L), then the SRBWWTP contribution drives the total. Therefore, as long as the SRBWWTP contribution is ensured to achieve the safety target, then it will not significantly increase the risk to water users of the Logan River.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

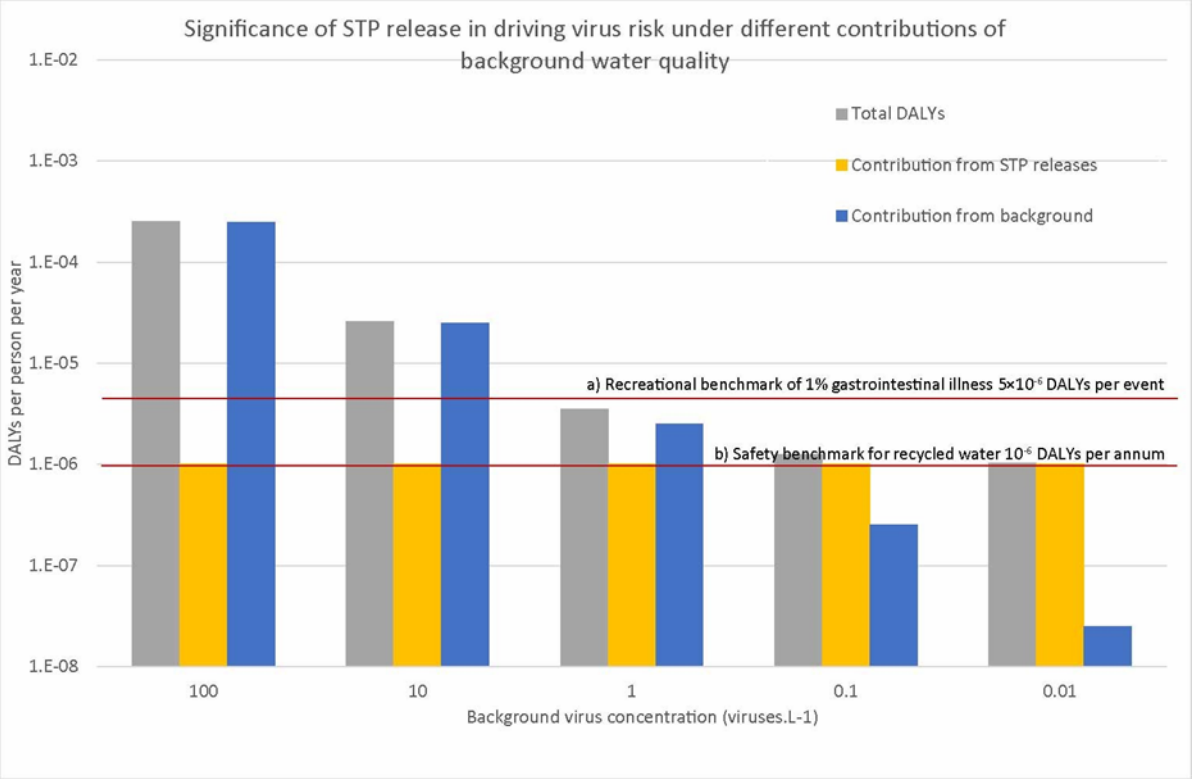


FIGURE 9-29 SIGNIFICANCE OF WWTP RELEASE DRIVING VIRUS RISK UNDER DIFFERENT CONTRIBUTIONS OF BACKGROUND WATER QUALITY

9.3.3.5 Defining a Safety Benchmark for Environmental Release

Given that there is no enteric pathogen tolerable risk target for environmental releases, the 1×10^{-6} DALY per person per year has been adopted in this analysis. This is the risk benchmark used in the AGWR and proposed for the Australian Drinking Water Guidelines (ADWG) for involuntary risk exposures, where for the protection of public health the risk must be so low it should be assumed to be close to zero. For recreational exposures, typically a higher risk level is tolerated at less than 1% risk of credible acute gastroenteritis for Category A (high quality waters) (NHMRC 2008) per recreation event (e.g. per swim). The difference between this recreational benchmark and the 10^{-6} DALY is illustrated in Figure 9-29. This indicative recreational target is calculated assuming that the 1% illness was caused by norovirus using the current DALY weighting per case of 5×10^{-4} (Gibney et al. 2014) noting that this tolerable risk is allowable per recreational exposure, whereas the AGWR and ADWG have an annualised target.

This illustration highlights that the tolerable consumption volumes calculated in this analysis are conservative with respect to recreational use, and appropriate for all water users.

9.3.3.6 Wet weather events

The results discussed here are for the risk from enteric viruses under normal dry weather conditions.The loading to the river and the performance of the MOA will change during wet weather conditions when the WWTP may bypass elevated inflows (between 3 and 5 times ADWF). Usage practices in the river during such wet weather conditions are expected to be different to those for dry weather conditions. It is also understood that this event-driven risk profile, while an important consideration, will be addressed by ***disinfection of wet weather bypass flows from the SRBWWTP, either via UV or chlorination and de-chlorination***.

9.3.3.7 Summary

- Current levels of treatment/controls are adequate to protect Logan River water users from enteric bacteria and Cryptosporidium.
- Additional treatment/controls are needed to protect Logan River water users from human enteric viruses.
- Adding disinfection to provide a further 3 Log10 barrier for viruses, will increase this tolerable consumption volume to 6.2 L per year, and provide a much greater margin of safety.
- Disinfecting intermittent wet weather bypasses will also ensure no adverse pathogen related risks at such times.

9.4 Emerging Contaminants and Other Constituents of Concern

The need to review emerging contaminants in the Logan River and other potential contaminants from the proposed SRBWWTP arises from concerns raised by the local prawn farmers association. For this assessment, Water Technology sampled and tested waters in the Logan River (at three locations, in proximity to the site) for over 400 contaminants. The results of the testing are discussed in Chapter 7.

To assist with the review, Stantec provided estimates of contaminants that may be present in the treated effluent discharge from the SRBWWTP. This subsection is based on Stantec's reporting. As the WWTP and associated collection system has not been constructed, data collection is not possible to characterise the effluent from the WWTP. As such, discussions presented in this assessmernt are based on estimates for WWTP discharge quality only and the following should be noted:

- They are based on the concept design assumptions for WWTP discharge requirements (e.g. parameters that are included in a typical discharge permit (e.g. total nitrogen));
- Where parameters are not typically included in a typical discharge permit, values are presented from a comprehensive characterisation performed on another comparable WWTP located in Southeast Queensland (SEQ); and
- Information for samples taken at other WWTPs outside of Southeast Queensland have also been used for comparison where required.

9.4.1 Reference Values Based on Other WWTPs

Stantec provided contaminant values for various compounds detected in the effluent of another Southeast Queensland WWTP in their 'Southern Redland Bay (Shoreline) WWTP – Effluent Characterisation Technical Memorandum'. The data set from which the values were drawn consists of over 500 analytes, the vast majority of which were below the limit of reporting (LOR). Appendix H provides a summary of values for compounds from the total list of analytes. The values shown in Appendix H are the average and maximum values from the data set for each of the 'conventional' parameters and maximum values only for 'emerging contaminant' parameters.

The information provided in Appendix H is intended as a **guide** to what Southern Redland Bay WWTP effluent may comprise. We note that the catchment for the other SEQ WWTP included industrial waste contributions. As the Southern Redland Bay WWTP catchment will be entirely residential and is smaller than the catchment for the other SEQ WWTP, the values provided in Appendix H cannot be taken as completely representative. However, they do provide a reasonable estimate for environmental modelling and risk assessment purposes.

Appendix H also provides information for samples taken at the Beenyup WWTP in Western Australia, where samples were analysed for the same parameters as the SEQ WWTP. The data shown is the maximum value reported (or the LOR if this was never exceeded). The Beenyup WWTP data was selected because related reporting (see Southern Redland Bay (Shoreline) WWTP – Effluent Characterisation Technical Memorandum)

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

indicated that the catchment was mainly residential. We note that the Beenyup WWTP catchment is much larger than the Southern Redland Bay WWTP (of the order of 50 times larger). Consideration of this data needs to account for this difference.

Other information presented in Stantec's reporting also include:

- Monitored data from Self Point WWTP in Hobart, Tasmania;
- Sampled data of 28 antibiotics in secondary effluent from five municipal WWTPs in southeast Queensland sampled by Watkinson et. al in 2009; and
- Data from other international WWTPs.

9.4.2 Discussion

ANZECC (2018) water quality guidelines for the protection of aquaculture species provide appropriate water quality guideline values for physico-chemical parameters and toxicants, respectively, to be applied for use in general saltwater (brackish and marine water) aquaculture. Note that the guidelines provided in ANZECC are for limited contaminants and compounds only and do not cover all contaminants tested by Water Technology.

Physico-chemical stressors - A number of naturally-occurring physico-chemical stressors can cause adverse effects on aquaculture operations when influent water values are too high and/or too low. Some of the major stressors as per ANZECC (2018) are dissolved oxygen, hardness, pH, salinity and suspended solids. These stressors are addressed below:

- **Dissolved Oxygen** – The recommended guidelines for dissolved oxygen for saltwater production is >5 mg/L. We note that as per our assessments in Section 9.1.5, expected changes to DO within the Logan River Estuary in the vicinity of, and attributable to, the SRBWWTP effluent discharge and MOA are negligible. A median value of 6.6 mg/L was maintained for the three scenarios tested.
- **Alkalinity** – The prescribed guideline levels for alkalinity for saltwater production is >20 mg/L. The average total alkalinity detected in the reference SEQ WWTP as per Stantec's Southern Redland Bay (Shoreline) WWTP – Effluent Characterisation Technical Memorandum was 204 mg/L (maximum value detected was 266 mg/L). This is within the prescribed guidelines.
- **pH** – The pH guideline for protection of aquaculture species is prescribed to be 6.0 – 9.0. The pH of recycled water from the WWTP is expected to be well within this range (min pH 6.5, max pH 8.5, see Stantec's Southern Redland Bay (Shoreline) WWTP – Effluent Characterisation Technical Memorandum). This will therefore not have any impact on the water quality of the Logan River Estuary.
- **Salinity** – Changes in salinity in the Logan River were assessed in detail in Section 9.1.2. Negligible impacts on the salinity in the Logan River will occur. The salinity levels are expected to remain within the prescribed guideline levels (33 – 37 g/L for saltwater production and 3 – 3.5 g/L for brackish water).
- **Total Suspended Solids (TSS)** – We note that proposed membrane bioreactor process selected for the Southern Redland Bay WWTP will produce TSS levels far less than those prescribed in the guidelines due to the physical barrier to solids passage provided by the membranes. For purposes of characterizing WWTP effluent impacts, the TSS should be assumed to be < 5 mg/L, which is far less than the ambient level in the Logan estuary.

Inorganic toxicants (heavy metals and others) – A wide range of inorganic toxicants, particularly heavy metals, can be a problem in freshwater, brackish water and inshore marine aquaculture, especially in areas of human habitation that may be polluted. Trace quantities of metals are present in natural waters; however, their concentrations are generally greater in the vicinity of industrial processes (ore mining and processing, smelting plants, rolling sheet metal mills, textile and leather industries) and exhaust gases of motor vehicles and burning of other fossil fuels and not in the vicinity of WWTPs. As per ANZECC (2018) toxicant guidelines for protection of aquaculture species, those constituents of greatest concern to fisheries (including aquaculture) include

aluminium, arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel and zinc. Other inorganic toxicants include ammonia, chlorine, cyanide, fluoride, hydrogen sulfide, nitrite, nitrate and phosphates. Levels of calcium and magnesium are also important because they influence the hardness of the waters. These stressors of concern are addressed below.

We note regarding the following that the levels of inorganic toxicants in the discharge from the reference SEQ WWTP can be expected to be higher than those from the proposed SRBWWTP as the catchment the SRBWWTP will service does not include industrial wastewater and will be domestic wastewater only.

- **Aluminium** – Water quality samples from the Logan River were observed to have higher levels of aluminium than the prescribed guideline value (for aquaculture species) and were also higher than the maximum reported values at the reference SEQ WWTP. The average measured value for aluminium for the reference SEQ WWTP in isolation was slightly above prescribed guideline values. As such, water quality in the Logan River already exceeds desirable aluminium levels. If the SRBWWTP effluent matches the quality of the reference SEQ WWTP, discharges will be of a concentration that is less than ambient levels in the Logan River, and should contribute to an (albeit small) reduction in these levels. Hence, no detectable or adverse impact on aquaculture production is expected from the SRBWWTP.
- **Arsenic** – Levels of Arsenic were below the guideline value (for aquaculture species) at all sampled sites in the Logan River. The average measured values for the reference SEQ WWTP were also considerably below the prescribed guidelines. Therefore, no impact on aquaculture production is expected.
- **Cadmium** – Levels of Cadmium were below the prescribed guideline value (for aquaculture species) at all sampled sites in the Logan River. The average measured value for the reference SEQ WWTP was also considerably below maximum levels in the prescribed guidelines. Therefore, no impact on aquaculture species is expected.
- **Chromium** – Levels of Chromium were below the prescribed guideline value (for aquaculture species) at all sampled sites in the Logan River. The average measured value for the reference SEQ WWTP was also below maximum levels in the prescribed guidelines. Therefore, no impact on aquaculture species is expected.
- **Copper** – Levels of Copper were below the prescribed guideline value (for aquaculture species) at all sampled sites in the Logan River. The average measured value for the reference SEQ WWTP was also within the prescribed guideline level. Therefore, no impact on aquaculture species is expected.
- **Iron** – Iron levels at all sampled sites in the Logan River already exceed the prescribed guidelines. Average measured iron levels from the reference SEQ WWTP also exceeded guideline values, however, were less than half that of the levels in the Logan River. If the SRBWWTP effluent matches the quality of the reference SEQ WWTP, discharges will be of a concentration that is less than ambient levels in the Logan River, and should contribute to an (albeit small) reduction in these levels. Hence, no detectable or adverse impact on aquaculture production is expected from the SRBWWTP.
- **Lead** – Levels of Lead were below the prescribed guideline value (for aquaculture species) in all sampled sites in the Logan River. The average measured value for the reference SEQ WWTP was also within the prescribed guideline level. Therefore, no impact on aquaculture species is expected.

TABLE 9-5 TOXICANTS (METALS)

Parameter	Units	Maximum LOR used in sampling at the reference SEQ WWTP	Average Value reported at the reference SEQ WWTP	Maximum value reported at the reference SEQ WWTP	Upper Reach (High Tide)*	Upper Reach (Low Tide)*	Adjacent (High Tide)*	Adjacent (Low Tide)*	Lower Reach (High Tide)*	Lower Reach (Low Tide)*	Recommended guideline for saltwater aquaculture production*
Aluminium	mg/L	-	0.037	0.10	0.31	0.25	0.26	0.21	0.25	0.18	<0.01
Arsenic	mg/L	0.001	0.0017	0.0030	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.03
Cadmium	mg/L	0.0001	0.00057	0.001	<0.0008	<0.0008	<0.0008	<0.0008	<0.0008	<0.0008	<0.0005-0.005
Chromium	mg/L	0.001	0.003	0.01	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.02
Copper	mg/L	0.001	0.0047	0.027	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005
Iron	mg/L	-	0.17	0.28	0.4	0.34	0.33	0.27	0.31	0.23	<0.01
Lead	mg/L	0.001	0.003	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.001-0.007
Mercury	mg/L	0.0001	n/a	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.001
Nickel	mg/L	0.001	0.0022	0.003	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.1
Zinc	mg/L	-	0.055	0.26	0.0085	0.0045	<0.004	<0.004	<0.004	0.0091	<0.005
* ANZECC (2018) Toxicant guidelines for the protection of aquaculture species											

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

- **Mercury** – Levels of Mercury were below the prescribed guideline value (for aquaculture species) at all sampled sites in the Logan River. The limit of reporting (LOR) for mercury for the SEQ WWTP samples was below guideline values. Therefore, no impact on aquaculture species is expected.
- **Nickel** – Levels of Nickel were below the prescribed guideline value (for aquaculture species) at all sampled sites in the Logan River. The average measured value for the reference SEQ WWTP was also below the prescribed guideline level. Therefore, no impact on aquaculture species is expected.
- **Zinc** – Levels of Zinc were generally below the prescribed guideline value (for aquaculture species) at all sampled sites in the Logan River. The average measured value for Zinc at the reference SEQ WWTP exceeded the prescribed guideline level. Given SRBWWTP effluent is expected to be of a better quality than the reference SEQ WWTP, the slight degree of exceedance of the guideline value in effluent from the SEQ WWTP and the significant dilution of effluent in the MOA and once it reaches the Logan River, no impact on aquaculture species is expected.
- Others:
  - Whilst the short term 50th percentile value is assumed to be 3 mg/L as N as a discharge permit condition, typical ammonia values will be substantially less than 3 mg/L as N from the SRBWWTP.
  - Nitrate from the SRBWWTP recycled water is also expected to typically be less than 1 mg/L as N and nitrite is expected to typically be less than 0.2 mg/L as N.
  - The SRBWWTP will not be using chlorination as a disinfection process. Therefore, chlorides in the MOA are not expected.
  - Reported Cyanide levels from the reference SEQ WWTP were well below guideline values, therefore of no concern. No cyanide was detected in the Logan River.

Organic toxicants – ANZECC (2018) prescribes guideline values for a very limited number of detergents and surfactants, hydrocarbons derived from human activities (namely petroleum hydrocarbons), only five (4) pesticides (for saltwater production), phenolic compounds and polychlorinated biphenyls. Most of these originate from domestic, agricultural or industrial activities, and some are even used by aquaculture operations. No data were available to provide guidelines for antibiotics and antimicrobials.

Water Technology tested over 400 contaminants and compounds for this review to provide a better understanding of existing water quality in the Logan River. The results from the testing of existing conditions are discussed in Chapter 7, which we summarise as follows:

- For all existing and tested PPCPs, concentrations in the Logan River Estuary were significantly below guideline levels[9]. Low concentrations of PPCPs were recorded, despite considerable effluent loads from upstream WWTPs into the Logan River. For the reference SEQ WWTP, concentrations of PPCPs were significantly lower than the guideline values in the Queensland Public Health Regulation Standard Guidelines (2018) but were in some cases higher than ambient levels in the Logan River. This is not expected to be of concern with regard to the proposed SRBWWTP for the following reasons:
  - Although PPCPs in domestic wastewater are mainly contributed by human excreta, other direct and substantial methods of contribution include wastewater discharge from hospitals and industries. We note that the proposed SRBWWTP will service domestic wastewater only unlike the reference SEQ WWTP which currently also treats industrial wastewater. It is therefore unlikely that contributions from industries and healthcare will be present in the SRBWWTP recycled water.
  - The proposed plant is significantly smaller than the reference SEQ WWTP; and
  - The significant dilution of effluent in the MOA and once it reaches the Logan River.

[9] Queensland Public Health Regulation Standard Guidelines (2018)

- For all existing and tested EDCs, concentrations in the Logan River Estuary were significantly below guideline levels[3]. Low concentrations of EDCs were recorded, despite considerable effluent loads from upstream WWTPs into the Logan River. For the reference SEQ WWTP, EDC concentrations were significantly lower than the guideline values in the Queensland Public Health Regulation Standard Guidelines (2018), but in some cases, they were greater than ambient levels in the Logan River. This is not expected to be of concern with regard to the proposed SRBWWTP for the following reasons:
  - It will service domestic wastewater only unlike the reference SEQ WWTP which currently also treats industrial wastewater. Industrial wastewaters are known to have higher EDC concentrations of synthetic xenooestrogens (phthalates, PCBs, BPAs, etc.) and other componds such as pesticides, flame retardants, plastics, etc.;
  - The proposed plant is significantly smaller than the reference SEQ WWTP; and
  - The significant dilution of effluent in the MOA and once it reaches the Logan River.
- The levels of herbicides and pesticides were considerably lower than guideline values[10]. As for the reference SEQ WWTP, the levels of herbicides and pesticides were significantly lower than Australian Drinking Water Guidelines (ADWG) Health Values, but in some cases, were greater than ambient levels in the Logan River. This is not expected to be of concern with regard to the proposed SRBWWTP for the following reasons:
  - It will service domestic wastewater only unlike the reference SEQ WWTP which currently also treats industrial wastewater;
  - The proposed plant is significantly smaller than the reference SEQ WWTP; and
  - The significant dilution of effluent in the MOA and once it reaches the Logan River.
- All tested Polychlorinated Biphenyls (PCBs) were found to be below respective reporting limits in the Logan River. No reference data were available for comparison with other existing WWTPs. As such, the risk from PCBs is expected to be negligible. We note that:
  - Compounds classified as PCBs are predominanty found in coolants, industrial fluids (such as cutting oils, insulating fluids and hydraulic fluids), paints, adhesives and several other industrial uses. Domestic wastewaters are likely to have lower PCB concentrations as opposed to other wastewater sources.

In summary, we note that recycled water discharge into the MOA will not have adverse impacts on the Logan River Estuary for the following range of reasons:

- WWTPs upstream of the SRBWWTP site are older and are expected to have significantly lower treatment capabilities when compared to the proposed Southern Redland Bay MBR;
- SRBWWTP recycled water will be subject to UV disinfection prior to discharge into FSL and then into the MOA, which will also further 'polish' the recycled water from the WWTP.
- The capacity of the SRBWWTP is significantly lower than other facilities upstream;
- The proposed SRBWWTP will service domestic wastewater only unlike the reference SEQ WWTP which treats industrial wastewater contributions where higher concentrations of industry-specific contaminants are present; and
- The significant dilution of effluent in the MOA and once it reaches the Logan River.

[10] The Australian Drinking Water Guidelines (ADWG) Health Values

10 GROUNDWATER

10.1 Introduction

The potential impact on the local groundwater system of two activities planned in the area were considered as follows:

- Activity A – Mangrove establishment: Construction of a 15 m wide central channel with a depth profile ranging from 0.5 m AHD at the edges to -0.5 m AHD in the central channel and modifications of the surrounding MOA to achieve elevations of between 0.5 m AHD and 1 m AHD.
- Activity B – Recycled water disposal: Disposal of recycled water to the MOA via the mangrove channel once mangroves have established – Based on the expected wastewater generation and the requirement to allow up to 5 years for mangrove establishment prior to receival of recycled water, there will be zero discharge to the mangroves up until Year 4, when a minor discharge will occur during the wettest conditions (see Section 3.2). It is estimated that average discharge to the FSL and MOA will be around 19% by the end of Year 6 (assuming temporary irrigation continues), after which the system will receive an increased portion of the recycled water. At ultimate development, approximately 0.3 ML/day of recycled water is proposed to be reused with the remaining 2.4 ML/day discharged to the MOA.

10.2 Background

The MOA is located on an outer bend of the Logan River, about 7.5 km upstream from the mouth of the river. The proposed works are to be undertaken on the floodplain within 500 m of the river (Figure 2-1). In this area, the Logan River is tidal with salinity in the order of 30 g/L (See Section 9.1.2). The MOA is partly within the medium storm tide inundation area and fully within the high storm tide inundation area (Water Technology, 2020). During these events, the MOA is currently inundated with saline river water.

Geotechnical investigations by Douglas Partners (2019) found that the MOA is characterised by an upper clayey sand topsoil layer to depths of between 0.1 m and 0.3 m. The topsoil was underlain by alluvial soils comprising high plasticity, soft to firm sandy clay to depths of 0.7 m and 1.2 m and then loose clayey sand to depths of 2 metres (Douglas Partners, 2019). Free groundwater was observed in all 30 geotechnical test bores between 0.2 m and 1 m depth. It was reported that groundwater depths at the MOA are affected by climatic conditions, soil permeability and tidal conditions and levels are therefore expected to vary with time (Douglas Partners, 2019).

The MOA is located within the Logan-Albert Basin. There is no known groundwater management area listed for this area. The nearest recorded groundwater wells are more than 1 km away (Figure 10-1) and are reported to intersect the Bunya Phyllite/Neranleigh-Fernvale beds, described as Early Carboniferous to Late Devonian age sedimentary siliclastic and igneous mafic volcanic rocks. There are no recorded groundwater level or salinity data available for these wells.

Aquatic and terrestrial Groundwater Dependent Ecosystems (GDEs) are identified (with moderate confidence) near the MOA based on data from Queensland Globe (Figure 10-2 and Figure 10-3). Works to be undertaken for this project are in areas which have been previously cleared or have historically contained no vegetation. It is understood that most vegetation around the MOA will be retained, although some clearing of vegetation is required as part of this project. The Vegetation Clearing and Fauna Management Plan prepared by Saunders Havill Group should be referred to for further details.

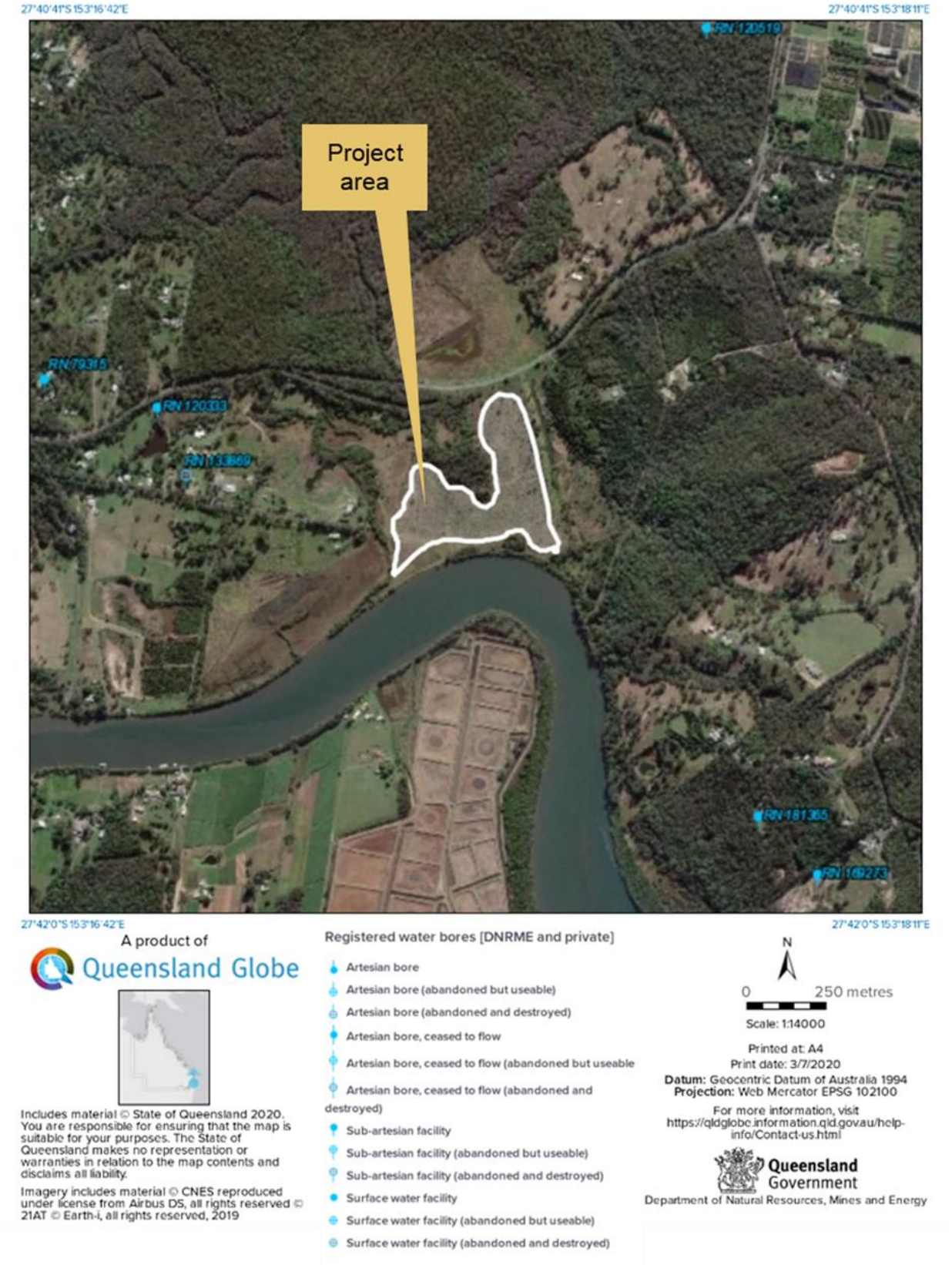


FIGURE 10-1 LOCATIONS OF REGISTERED GROUNDWATER WELLS SHOWN AS BLUE DOTS (SOURCE: QUEENSLAND GLOBE)

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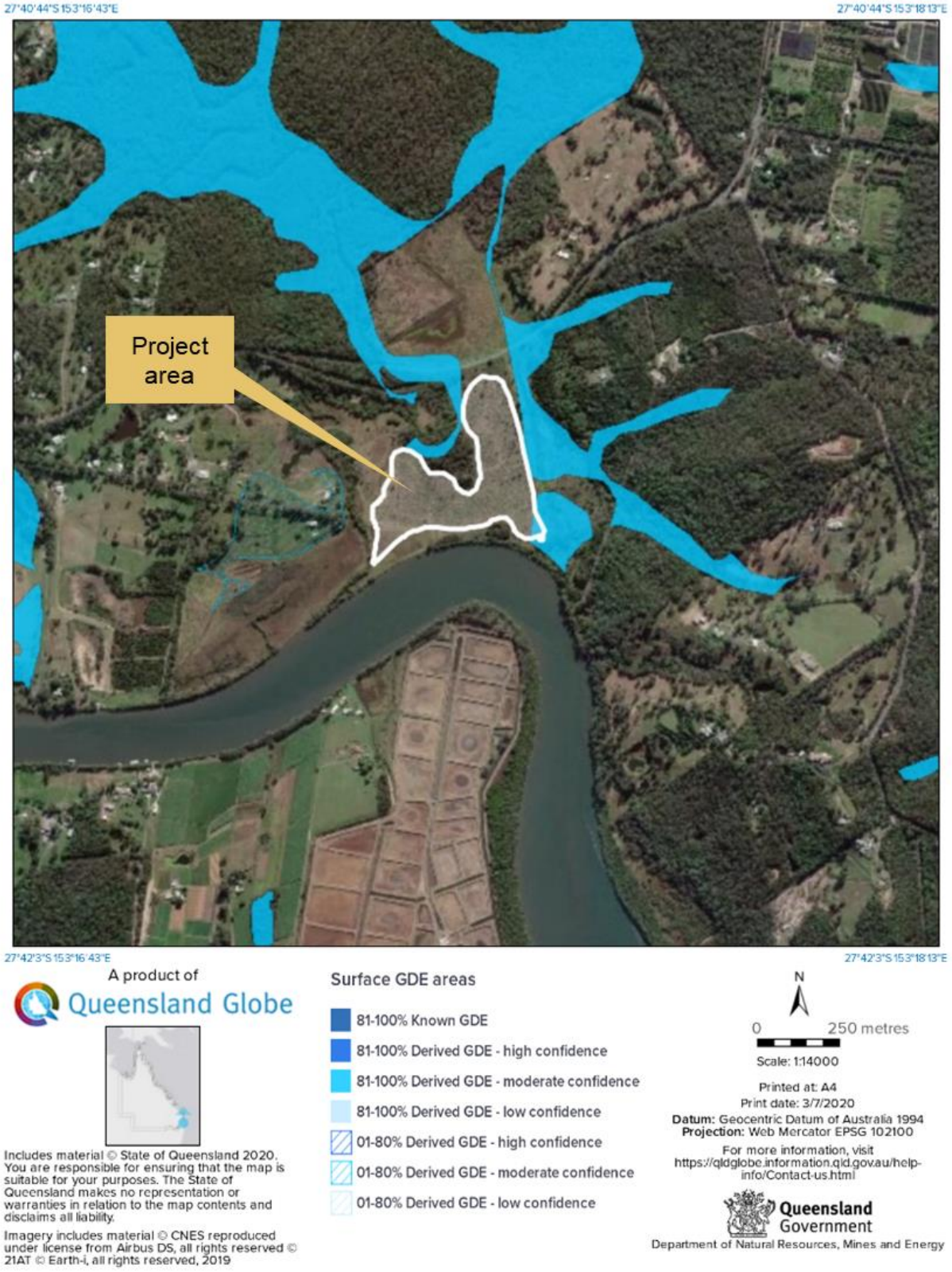


FIGURE 10-2 LOCATION OF POTENTIAL AQUATIC GDES, SHOWING AREA OF MODERATE POTENTIAL FOR AQUATIC GDES IN ALLUVIAL AQUIFERS IN PURPLE (SOURCE: QUEENSLAND GLOBE)

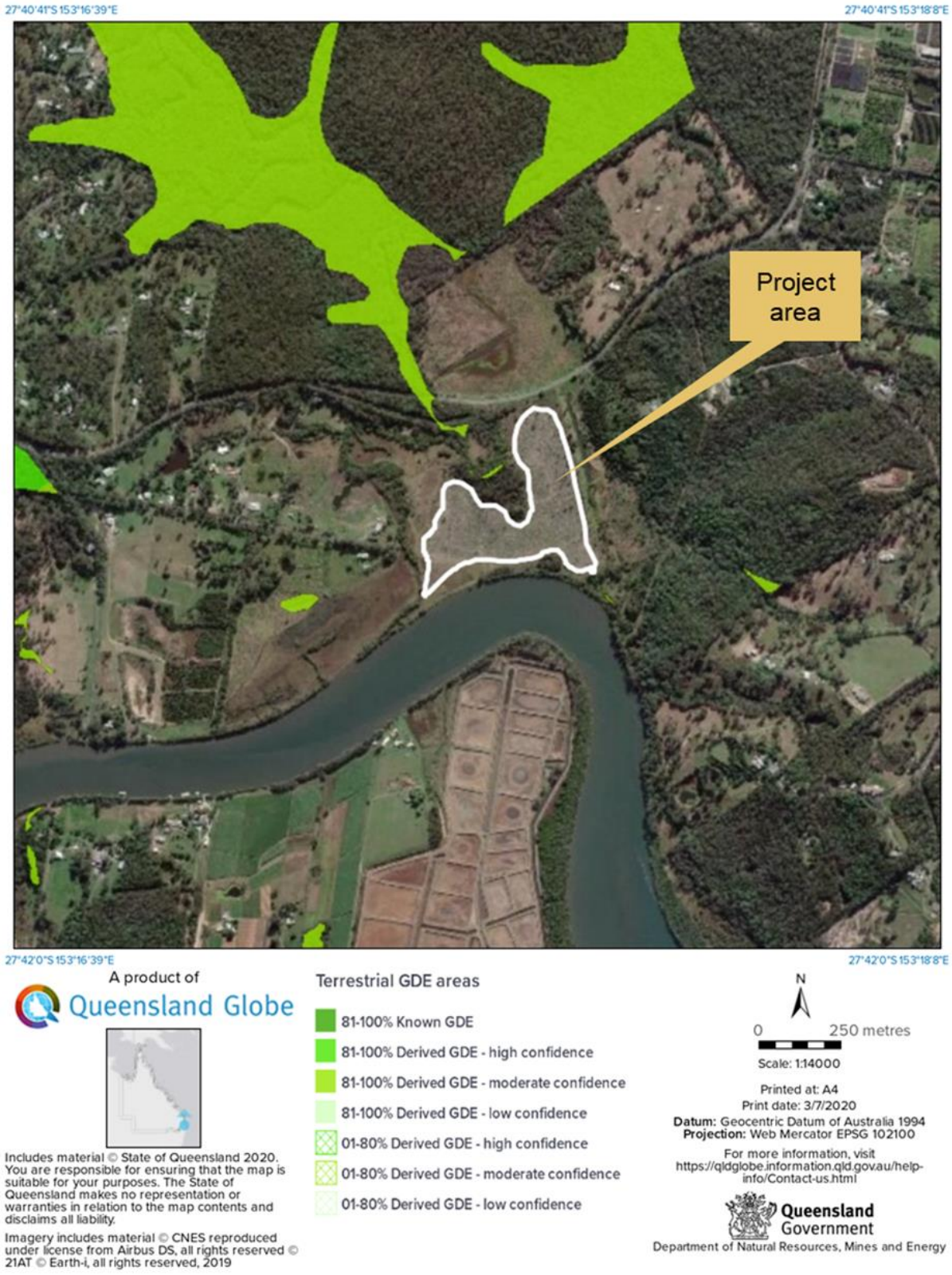


FIGURE 10-3 LOCATION OF POTENTIAL TERRESTRIAL GDES LISTED AS MODERATE POTENTIAL GDES IN ALLUVIAL AQUIFERS IN GREEN (SOURCE: QUEENSLAND GLOBE)

10.3 Activity A: Mangrove establishment

The design plan consists of a deeper central flow channel within the planned mangrove area and a modified peripheral 'mangrove growth area'.

Geotechnical assessments and testing for Acid Sulfate Soils (ASS) were undertaken by Douglas Partners (2019). The level of ASS material detected indicated that the MOA does not require an Acid Sulfate Soil Management Plan.

There is potential that the shallow alluvial aquifer will be intersected during construction of the central flow channel based on observed groundwater levels which are expected to occur from 0.2 m and 1 m below the natural surface elevation. If intersected, the groundwater is expected to be brackish to saline, however, there is currently no data on which to validate this assumption. The flow regime of the central flow channel is expected to be dominated by the tidal inflow and outflow from unidirectional inlet and outlet structures. It is expected that levels within the MOA will be maintained within those of natural tidal variations in the Logan River.

Consideration of dewatering impacts during construction is outside the scope of this report and will be addressed separately.

10.4 Activity B: Treated recycled water disposal

After the MOA is constructed and the mangroves are established in the basin, the area will be used for the disposal of recycled water which will be of acceptable quality for disposal onto parks and reserves within the proposed development.

Assessment of the surface water quality impacts of the proposed development found negligible impact on salinity and nutrient levels in the Logan River (see Section 9.1).

Some infiltration of the recycled water to the shallow alluvial aquifer is expected, however, as there are no nearby groundwater users and groundwater in the shallow alluvial aquifer is expected to naturally discharge back towards the Logan River, the risks of such are low. Depending on the operational regime of the FSL and MOA, groundwater may also discharge into the system when inputs from the Logan River and WWTP are restricted. Importantly, no proposed volume profiles are currently available. The discharged volume profile should be acceptable to the receiving environment.

10.5 Summary

The MOA is located within an estuarine environment on the lower reaches of the Logan River. We note that:

- There are no known groundwater users within 1 km of the MOA and without further information, any impacts to the shallow alluvial aquifer are expected to be localised and low; and
- The MOA is within the medium storm tide inundation area and fully within the high storm tide inundation area. The groundwater salinity of the alluvial aquifer is expected to be reflective of that in the Logan River, which is equivalent to seawater in this location.

11 FLOODING AND STORMWATER

11.1 Existing Site Elevations

The Southern Redland Bay Waste Water Treatment Plant site (the site) is located to the south of 38 Longland Road, Redland Bay, on an outer bend of the Logan River approximately 7.5 km upstream of the river mouth. LiDAR and site-specific surveys have been combined to generate Figure 11-1. The eastern areas of the site are relatively steep and high whilst the central and western areas are relatively flat and low lying.

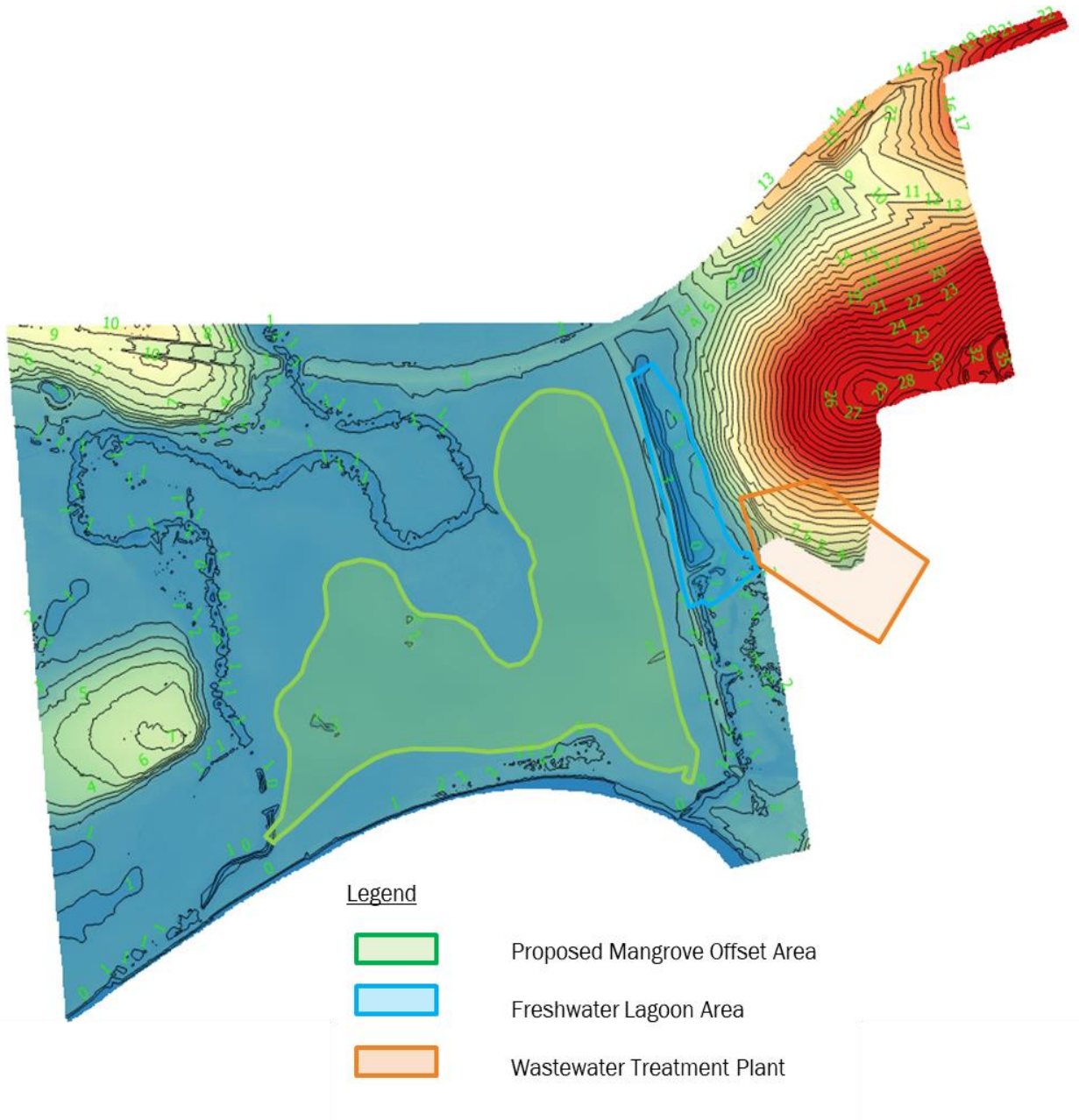


FIGURE 11-1 EXISTING SITE ELEVATIONS

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

11.2 Flood Hazard Mapping

According to the Redland City flood and storm tide overlay, the site is mapped under the following flood and storm tide hazard areas:

- 2016 storm tide inundation area;
- 2100 storm tide inundation area; and
- Flood prone area.

The proposed Mangrove Offset Area (MOA) and Freshwater Storage Lagoon (FSL) are located within the flood and storm tide hazard areas, whereas the Waste Water Treatment Plant (WWTP) itself is located outside / above these areas. See Figure 11-2 for the Redland City Flood and Stormtide Overlay.

11.3 Developed Case Site Elevations and Expected Tide Levels

The design intent of the MOA is principally to maximise the area suitable for future mangrove colonisation within the constraints of the existing native vegetation and surface elevations. The proposed excavated area consists of a subtidal[11] channel and an intertidal[12] area. It is the intertidal area which will be colonised by mangroves. The elevation of the proposed intertidal area was informed using the vertical distribution (with respect to the tide) of mangroves within the adjacent Logan Estuary. The mangroves in the adjacent Logan Estuary colonise intertidal areas from Mean Water Level (MWL) up the Mean High Water Spring Level (MHWSL).

The water levels within the MOA are dependent on those in the adjacent Logan River Estuary and the width and elevation of the culverts which form the inlet and outlet of the MOA. The numerical model detailed in Section 9 was used to size these culverts. The culverts were sized so that the entire excavated intertidal area, excluding the subtidal chanel, would readily be colonised by mangroves. Thus, the culverts were sized so that the MWL and MHWSL within the site coincided with the lower and upper bounds of the excavated intertidal area.

Land elevations for the existing and developed cases are depicted in Figure 11-3 and Figure 11-4. Figure 11-4 depicts how the excavated subtidal area (light blue) extends from -0.5 to 0.3 m AHD and the excavated intertidal area (light green and greenish yellow) from 0.3 to 1.0 m AHD. With the appropriately sized culverts, the modelling indicated that the MWL and MHWSL within the site would be approximately 0.3 m and 1.0 m respectively. Thus, it can be expected that mangroves will stabilize the transition between the subtidal channel and intertidal area and extend to the upper limit of the excavated intertidal area.

During very large spring tides, the MOA is inundated from behind via Serpentine Creek. During these tides, areas colonised by existing salt couch and other native vegetation within the site are also temporarily inundated.

[11] Subtidal areas remain submerged at low tide.
[12] Intertidal areas are exposed during low tide and submerged during high tide.

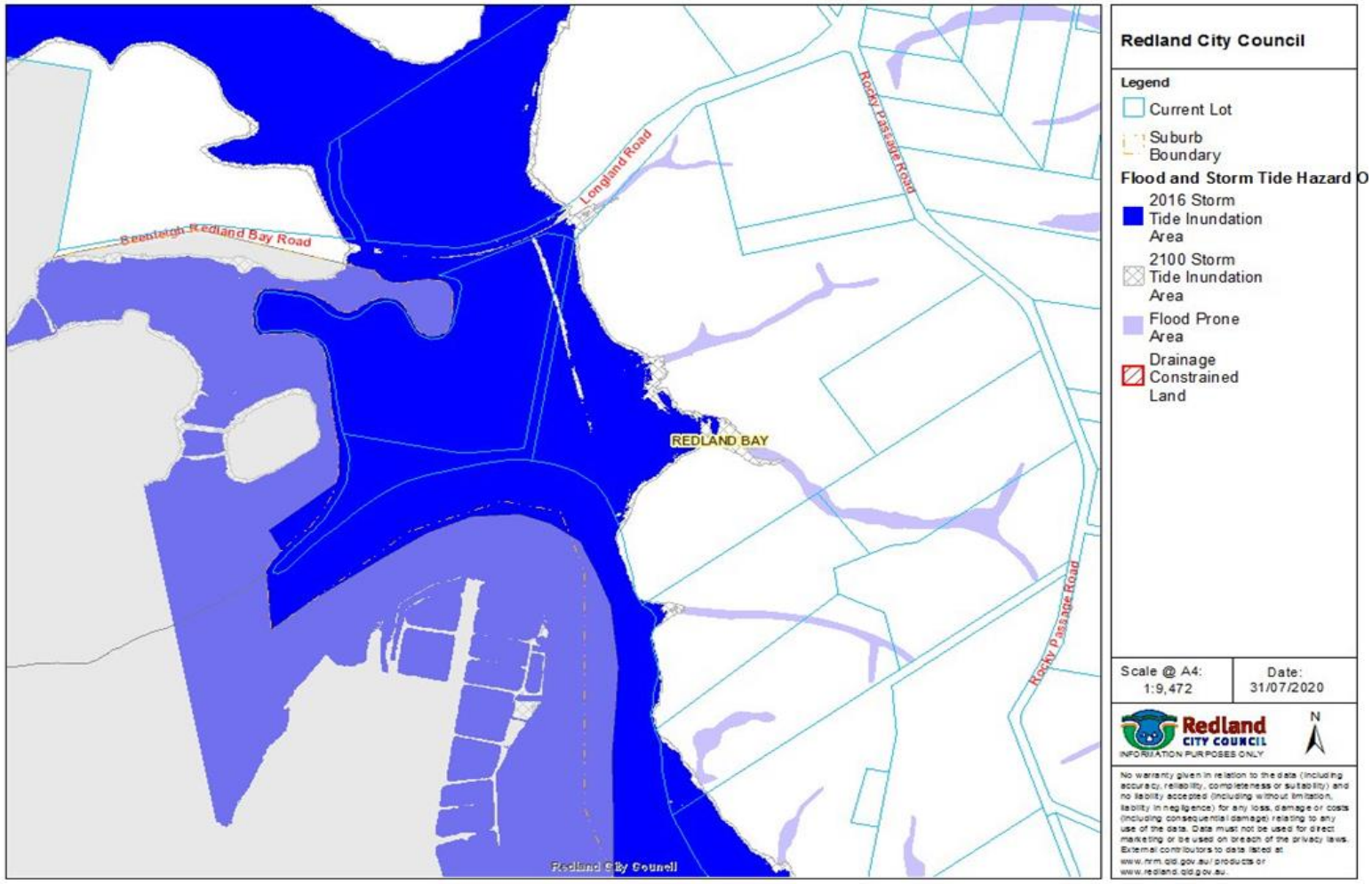


FIGURE 11-2 REDLAND CITY FLOOD AND STORMTIDE OVERLAY

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

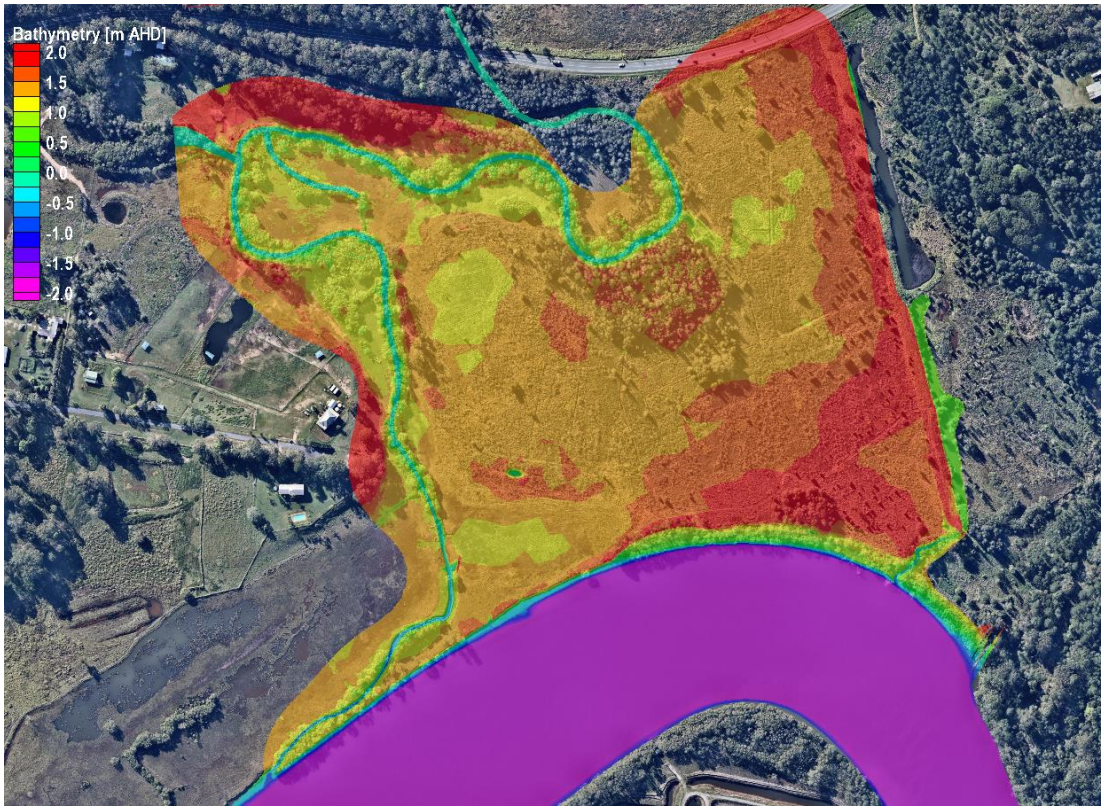


FIGURE 11-3 EXISTING SITE ELEVATIONS

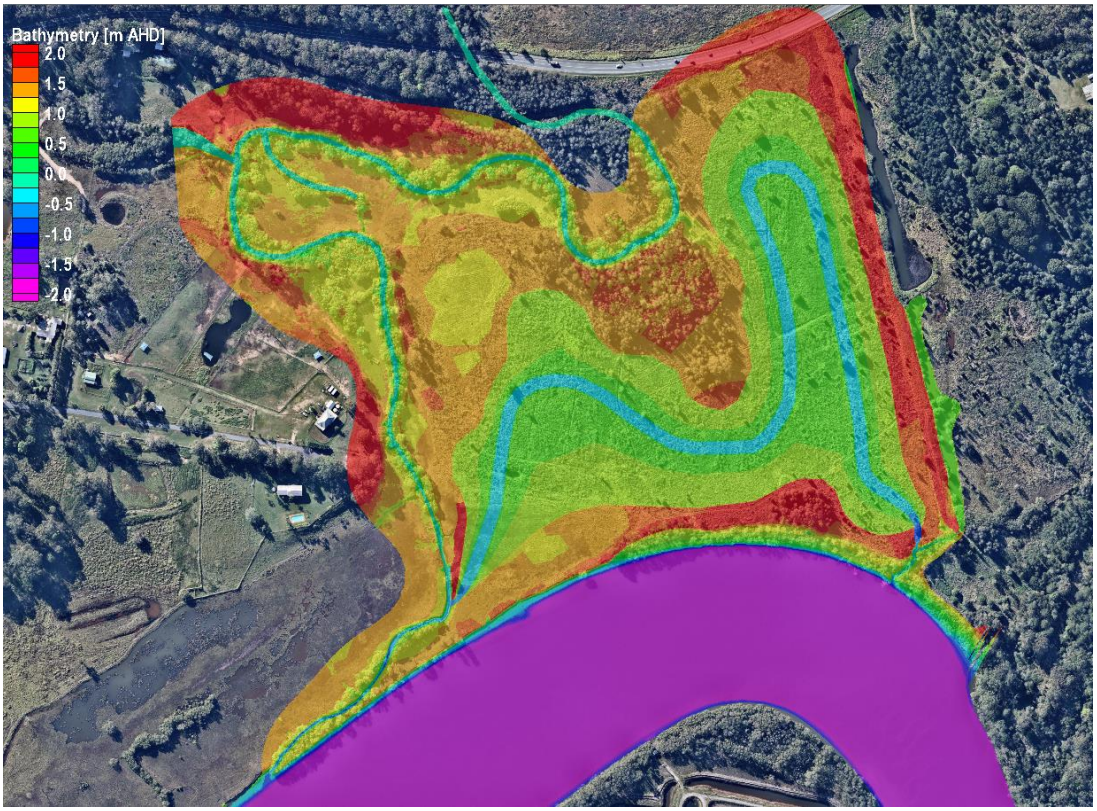


FIGURE 11-4 PROPOSED ELEVATIONS

11.4 Flooding of the Mangrove Offset Area

Mangrove die-offs following rainfall related flooding are almost always related to damage sustained from elevated flood currents and associated debris and/or the smothering of roots and leaves with sediment deposits. These die-offs are largely natural processes which occur following large and infrequent (extreme) events, such as the 2011 Brisbane River flood. Apart from extreme events, mangroves are largely unaffected by the temporary inundation resulting from rainfall or storm tide related flooding.

As the MOA does not constrict the existing natural waterways, the downstream flow of rainfall related flood waters from the catchment will not be hindered. The same applies for the upstream flow of storm tide related flood waters.

Proposed infrastructure within the MOA, such as the site access footpath and sediment basin can be flooded without significant damage or inconvenience.

11.5 Flooding of the Freshwater Storage Lagoon and Waste Water Treatment Plant

Sustained and heavy rainfall increases both the natural flows into the FSL and the risk of erosion over the relatively steep topography on which the WWTP is to be constructed. The concept rehabilitation plan encompassing the WWTP and FSL is provided in Figure 2-5. The plan includes measures to mitigate impacts from elevated catchment flows and strategies to manage stormwater runoff. The plan includes several management zones, specifically:

- Management Zone 1: Drainage Swale – A drainage feature designed to collect stormwater from the catchment and convey it into the MOA. To be densely planted with salt-tolerant groundcovers.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

- Management Zone 2 and 4: Weir / Overflow – A weir feature to manage recycled water levels in the FSL. The weir will drain excess recycled water from the FSL to the MOA. The drainage feature/watercourse will be densely planted with native salt-tolerant groundcovers to provide soil stabilisation.
- Management Zone 2: Downstream Stormwater Outlet – An outlet is included to convey stormwater from the non-MOA sections of the site (eastern side) into the FSL. The outlet will be stabilised with natural fibre matting and dense planting of native groundcovers.
- Management Zone 5 – Drainage feature/watercourse is included around the WWTP. Native groundcovers will be retained along the drainage line and dense planting of suitable groundcover species will provide soil stabilisation.

11.6 Sea Level Rise

Sea level rise is a phenomenon resulting from the increased concentration of greenhouse gases in the atmosphere, the subsequent warming climate, the subsequent melting of freshwater reserves in glaciers, and the subsequent increased volume of the oceans. Elevated sea levels result in elevated tide levels and subsequently elevated flood levels in low lying areas, be they rainfall or stormwater related.

Unlike for the brief influences of flooding, mangroves are susceptible to subtle yet sustained changes in tide levels. Thus, the MOA and its associated vegetation will be required to adapt to sea level rise. It is possible that the rate of sediment deposition in the MOA will be equivalent to that of sea level rise, in which case there would be minimal change to the distribution of intertidal vegetation over the coming decades. If sediment deposition is not equivalent, then it can be expected that the lower reaches of the MOA would become mudbanks, which are in themselves important habitat. In the latter scenario, it can also be expected that the mangroves will encroach into areas currently colonised by salt couch and other native vegetation. Again, this gradual migration of the mangroves can be expected to occur over several decades.

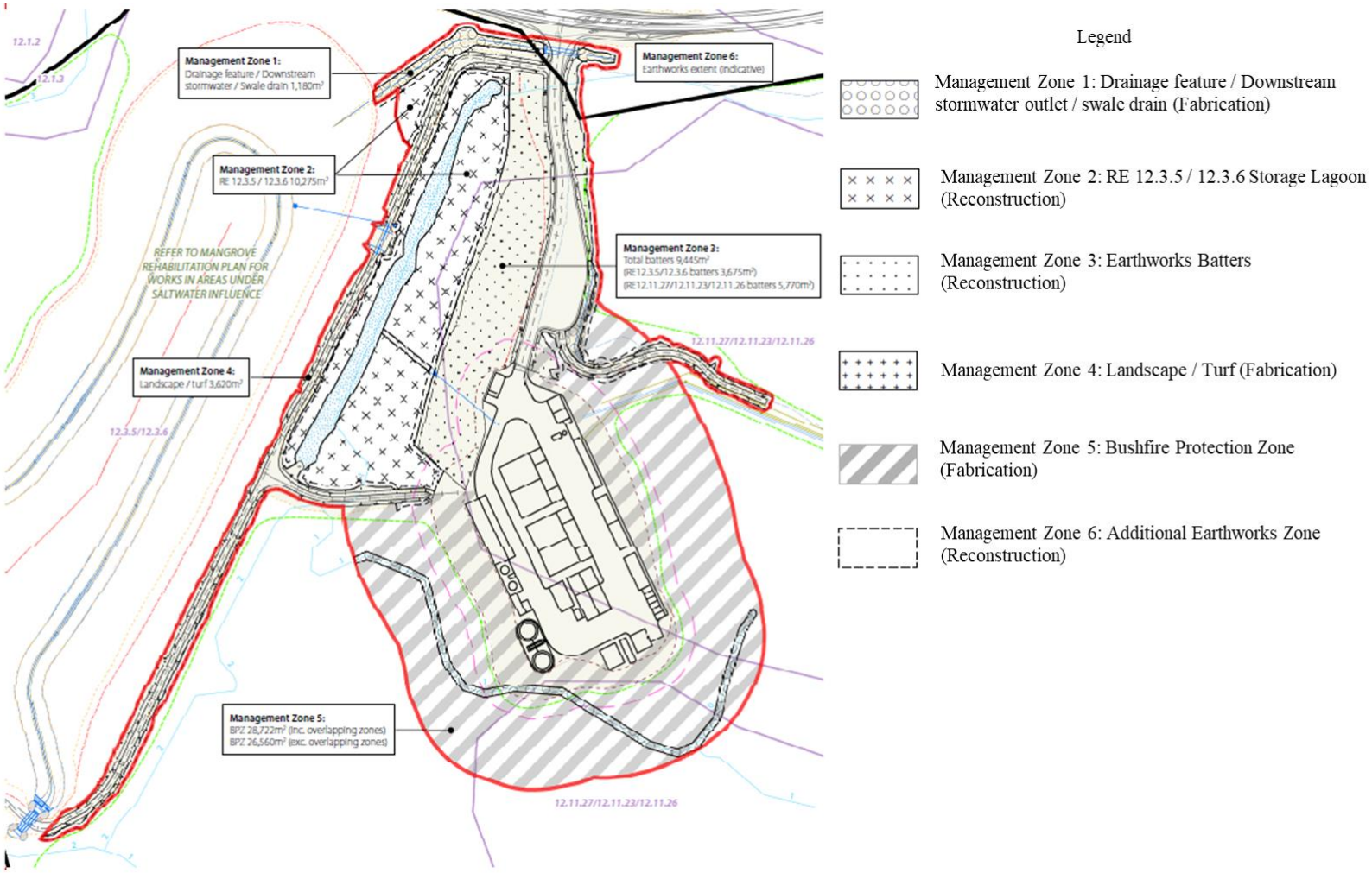


FIGURE 11-5 SOUTHERN REDLAND BAY WWTP – CONCEPT REHABILITATION PLAN MANAGEMENT ZONE

12 WATER QUALITY MONITORING AND MANGROVE MANAGEMENT PLAN CONSIDERATIONS

12.1 General Considerations

SRBWWTP - The nature of the proposed SRBWWTP design is somewhat unique due to the inclusion of the on-site MOA. Due to the MOA being the primary receiving environment (as a land-based discharge) of the Southern Redland Bay WWTP, and variability in water quality in this area being subject to external tidal and climatic influences, it is recommended that the water quality management plan for the recycled water be developed using water quality parameters with the discharge from the WWTP as the key reporting metric, prior to its passage into the Freshwater Storage Lagoon (FSL). It is therefore anticipated that water quality management criteria for the SRBWWTP will be consistent with those of other WWTPs upstream in the Logan Estuary for the construction and operational phase of the development.

Freshwater Lagoon - Recycled water from the proposed WWTP will pass through the FSL commencing Operational Phase Year 4, Phase 3 (see Section 3.2 for phases involved). The FSL will act as a temporary storage facility for recycled water and for potential stormwater runoff from the surrounding sub-catchment. As the FSL is not intended to provide any significant water quality treatment function for recycled water, a detailed water quality management plan is not necessary. However, regular inspections of the general health of the FSL (such as weed invasion or algal blooms) can be included as a part of a simplified water quality monitoring program. The presence of leaf litter and other gross pollutants in stormwater runoff can be noted through visual inspections on an ongoing monthly basis, especially after large rainfall events.

Mangrove Offset Area - The MOA will receive recycled water from the proposed WWTP after its passage through the FSL commencing Year 4, Phase 3 (see Section 3.2 for phases involved). Recycled water from the WWTP is not anticipated to have any detrimental impacts on the MOA or in the rehabilitation and establishment of mangroves. It is recommended that an appropriate monitoring program be included in overall site water quality management planning to monitor the establishment period and overall mangrove health in the MOA commencing immediately after the site is constructed and then tracking the system as the mangroves establish and transition from having smaller to progressively larger volumes of recycled water discharged to them. We anticipate that there will be considerable scientific interest in this system and that external researchers will be interested in supporting and undertaking this recommendation.

An appropriate overall system monitoring program is recommended in Section 12.2 for the proposed MOA and FSL, whereby monitoring will assess water quality and other matters to ensure that mangrove health is maintained. The proposed monitoring program also involves regular visual inspections to check the presence of gross pollutants other than expected leaf litter from the mangroves and surrounding vegetation.

12.2 Monitoring Program

The proposed monitoring program incorporates ongoing visual inspections and field data collection and monitoring to identify issues (if any) with water quality within the MOA and FSL. Personnel responsible for monitoring activities must ensure that all water resource data are acquired and stored to the standards specified in accordance with the Queensland Environmental Protection Agency Water Quality Sampling Manual, AS 2031:2001 and AS/NZS 5667.1:1998.

The monitoring program has been devised for application from project commencement. It is recommended that the WQMP be modified/updated with subsequent operational works approval. It is important that the WQMP is revised on an ongoing basis as the MOA development progresses from the Development Phase to the Operational Phases.

In addition to monitoring in the MOA and FSL, it is recommended that water quality data from the Healthy Land and Water (HLW) Ecosystem Health Monitoring Program (EHMP) be used to assess any changes in ambient water quality in the Logan Estuary. EHMP site E00212 is in close proximity to the Logan River – Serpentine Creek junction which is the proposed location of the MOA tidal outlet (see Figure 6-1 and Figure 6-2).

It is recommended that historic and ongoing water quality data from the HLW EHMP be used to assess any changes in ambient water quality in the Logan Estuary during the construction and establishment phases of the development. This is a common approach adopted to assess the impact of WWTP discharges elsewhere in the Logan River and in SEQ.

TABLE 12-1 MONITORING PROGRAM (MOA AND FSL)

Action	Where	Procedures	Frequency
Overall ecosystem condition assessments	MOA	Aerial imagery (drone) and repeatable transect surveys	Annual
Routine algal and weed monitoring	MOA/Freshwater Lagoon	Visual inspection	Monthly
Reactive water quality monitoring (in response to complaints, events, etc.)	MOA/Freshwater Lagoon	Visual and/or sampling	As required
Inspection and management of water levels (depths) for sediment removal within the waterbody (MOA/freshwater lagoon)	MOA/Freshwater Lagoon	Visual inspection and monitoring	Every 12 months
Inspection and management of pests (birds, fish, etc.)	MOA/Freshwater Lagoon	Visual inspection	Quarterly or as required
Litter monitoring and removal	MOA/Freshwater Lagoon	Visual inspection	Monthly
Water quality testing/monitoring; Tested parameters: ■ pH ■ Salinity ■ Total Nitrogen ■ Nitrogen Oxides ■ Ammonia ■ Total Phosphorus ■ Filtered reactive Phosphorus ■ Dissolved Oxygen ■ Total Suspended Solids ■ Turbidity ■ Temperature ■ E. coli ■ Enterococci	MOA only	In-situ sampling and lab testing	Annual or reactive monitoring as required
General observations noted: ■ Odours ■ Colour	MOA/Freshwater Lagoon	Visual inspection and monitoring	Monthly

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

TABLE 12-2 WATER QUALITY MONITORING CHECKLIST (MOA AND FSL)

WQMP Checklist				
Date: DD/MM/YY Inspection description: Personnel:				
	Y	N	Action(s) taken (details)	Future action(s) required (details)
Routine water quality monitoring conducted?				
Routine algal and weed monitoring conducted?				
Reactive water quality monitoring (in response to complaints, events, etc.) conducted?				
Inspection and management of water levels (depths) for sediment removal and dredging within the waterbody completed?				
Inspection and management of pests (birds, fish, etc.) conducted?				
Inspected for litter monitoring and removal?				
General observations: Any change in odours identified? Any change in colour identified?				
Is a follow–up required? If yes, when?				
Comments:				Signature:

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

13 CONCLUSIONS AND RECOMMENDATIONS

13.1 Conclusions

The Southern Redland Bay WWTP and associated infrastructure have been shown by the wide range of studies documented in this report to be able to be constructed such that appropriate State sanctioned urban development works in the Southern Redland Bay region can proceed with no adverse water quality impacts associated with the collection, treatment and disposal of generated wastewater. Importantly, not only can no adverse water quality impacts be anticipated, but at the same time a highly innovative and sustainable solution encompassing advanced wastewater treatment, recycled water reuse and environmental offsetting actions will be delivered which very much 'raises the bar' for future solutions of this nature in South East Queensland and further afield.

Of note, as well as a water quality solution, the just under 10ha Mangrove Offset Area to be delivered in association with the project, which will be constructed in conjunction with the Southern Redland Bay WWTP, will:

- Provide valuable habitat for estuarine flora and fauna species;
- Reduce carbon emissions through (a) removal of current CO_2 discharges from waterlogged soils on the site and subsequent in situ sequestration of carbon within the new mangrove forest and (b) reducing the need for recycled water to be pumped long distances to an otherwise potentially suitable discharge location in Southern Moreton Bay;
- Provide a location of mangroves to 'retreat' in the event of predicted sea level rise, an attribute identified by researchers as being of limited capacity of the Moreton Bay region; and
- Provide additional flood storage to the lower Logan River system.

13.2 Recommendations

Key recommendations made regarding this project are as follows:

- Given the new and innovative nature of the Mangrove Offset Area element of the project, appropriate efforts should be undertaken to gain as much scientific knowledge and insight as possible during the establishment and operational phases of the project. This should target (at least) the following key areas of interest:
  - Mangrove establishment/species progression;
  - Nutrient and organic sequestration within the Mangrove Offset Area;
  - The ecological characteristics of the Mangrove Offset Area as it develops and matures;
  - The impact/benefits of the system regarding carbon dynamics; and
  - Water quality and ecological relationships and linkages between the MOA in the Logan estuary.
- The coupled nature of the Southern Redland Bay WWTP and the Mangrove Offset Area itself also provides a somewhat unique opportunity to study the impact/efficiency of conventional sewage treatment techniques when coupled with a nature-based polishing/offset solution.

14 PRE-LODGEMENT COMMENTS AND RESPONSES

Pre-lodgement material and reporting was issued to the Queensland Government State Technical Agencies for their review and comment. Table 14-1 and Table 14-2 provide a summary of responses to comments relating to the preceeding version of this report raised by Department of Environment and Science (DES) and Department of Agriculture, Water and Fisheries (DAF), respectively, this report being entitled R01v03_20020099_Southern_Redland_Bay_Stage_3_Assessments.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

TABLE 14-1 RESPONSES TO DES COMMENTS

Item	DES Comment	Watertech Response
State Code 8: The document states - "Currently the site is intermittently inundated by tides of the order of Mean High Water Springs via Serpentine Creek and other small waterways. Once developed, incoming tides will inundate the Mangrove Offset Area via a unidirectional inlet to the east of the site and then drain out through a unidirectional outlet to Serpentine Creek to the west of the site. The Site will experience regular inundation during all tidal cycles".	This statement signifies the need for the applicant to mitigate and manage the risk of inundation and coastal hazards over the subject site. It is noted that the applicant has provided evidence that the wastewater treatment plant will be raised to a minimum level of 10m AHD and they will implement erosion and sediment control measures into the design of the proposed development	This is correct. The WWTP site will be above 10m AHD and erosion and sediment control measures will be implemented into the design proposed development. We also note that certain site levels (such as for the MOA) are designed for intentional inundation. The proposed vegetation (mangroves) within the MOA is intended to inundate and as such, no mitigation is required.
State Code 8: The document states - "The establishment of the Mangrove Offset Area (MOA) will change the tidal prism of the river. At the full operational capacity of the WWTP and upon complete establishment of the mangrove/saltmarsh habitats, the change in tidal prism of the Logan estuary was estimated to be between 0.6% (during neap tides) and 1.5% (during spring tides). These changes are small and will have no impact on bed and bank stability or coastal processes within adjacent sections of the Logan River. Therefore, erosion/migration of the riverbank is anticipated to be best managed by maintaining currently stable and well vegetated riverbanks. It is anticipated that long-term recession of foreshores due to longshore sediment transport differentials, migration and geomorphologic changes to estuaries and tidal inlets, and impacts of other works and structures along the shoreline will not have a detrimental impact on the Logan River".	Changing tidal prism is a consideration under the State code 8. Long term recession of the foreshore may need further mitigation to prevent degradation of the Logan Riverbanks.	The predicted changes in tidal prism are small (1.7% and 0.3% during spring and neap tides, respectively) and will have no impact on bed and bank stability or coastal processes within adjacent sections of the Logan River. Long-term recession of foreshores due to longshore sediment transport differentials, migration and geomorphologic changes of the bank will not result from the MOA but are more likely to be natural coastal processes associated with the Logan River estuary. We note that sea level rise which is occurring will have a far greater impact on any such processes than any minor changes associated with the MOA. See Section 9.2 for further details.

Item	DES Comment	Watertech Response
State Code 8: The document states – ”Although Serpentine Creek is outside the site boundaries, it is important that the vegetation along the banks of Serpentine Creek is maintained and preferably revegetated to mitigate any potential for localised erosion.”.	More information regarding how the proposed revegetation will be managed on Serpentine Creek and maintained will be required.	Revegetation works will be required in Serpentine Creek. It is also recognised that inter tidal, salt marsh and surrounding low lying areas located along Serpentine Creek are culturally significant areas for Traditional Owner groups. Part of this area will be disturbed to facilitate construction of a MOA. It is recommended that Traditional Owners be consulted regarding the long-term management of these areas, inclusive of opportunities for their involvement in rehabilitation and other related management activities. Following such consultation, more details of the works that are proposed can be provided. See the Draft Operational Environmental Management (OEMP) by Stantec and the preliminary Site-Based Management Plan by Water Technology for further details.
State Code 8: The document states – "Disposal of sediment from the sediment basin will need to be addressed and a management plan developed”.	This will need to be managed accordingly with a plan submitted as part of the future development application.	This has been addressed in the preliminary Site-Based Management Plan (Water Technology). The Site-Based Management Plan is a working document and will be updated on an ongoing basis throughout the detailed design and subsequent site construction and operation process.

TABLE 14-2 RESPONSES TO DAF COMMENTS

Item	DAF Comments	Watertech Response
Agriculture	Section 9.4 outlines 'the need to review emerging contaminants in the Logan River and other potential contaminants from the proposed SRBWWTP arises from concerns raised by the local prawn farmers association'. Considering the prawn farm opposite the proposed WWTP is operational (along with other adjacent aquaculture farms), it is strongly recommended further consultation occurs with the Australian Prawn Farmers Association (APFA) and adjacent aquaculture farmers not members of the APFA, to ensure their concerns have been addressed. DAF is happy to facilitate discussions with farm operators.	The existence of the operational prawn farm opposite the proposed WWTP along with other adjacent aquaculture farms is acknowledged. Water Technology and Lendlease have consulted with the Prawn Farmers Association over the past year (during both the due diligence process and then followed by the design process). This engagement with the PFA is ongoing.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

Item	DAF Comments	Watertech Response
Agriculture	Section 9.4.2 outlines contaminants and parameters relevant to aquaculture. It is noted that certain indicators exceeded prescribed guidelines (e.g. Aluminium, Iron, Zinc). The load limits in the Logan (i.e. levels sampled in the Logan River already exceeding guidelines) vs effluent from the SRBWWTP possibly increasing such loads should be considered.	As discussed in Section 9.4.2, the average measured values for some contaminants (such as aluminium, iron and zinc) for the reference SEQ WWTP were slightly above prescribed guideline values. However we note the following: ■ Water quality in the Logan River already exceeds desirable levels for some contaminants. Assuming that the proposed SRBWWTP effluent matches the quality of the reference SEQ WWTP, discharges will be of a concentration that is actually lower than ambient levels in the Logan River, and should contribute to an (albeit small) **reduction** in these levels in the Logan River by way of dilution. ■ The information provided for the reference SEQ WWTP is **intended as a guide** to what Southern Redland Bay WWTP effluent may comprise. **We note that the catchment for the other SEQ WWTP included industrial waste contributions**. The SRBWWTP catchment will be entirely residential. It is highly likely that the ultimately generated wastewater effluent will contain lower concentrations of contaminants than those associated with the reference SEQ WWTP.

Item	DAF Comments	Watertech Response
Agriculture	Section 3.3.2 outlines the Mangrove and Salt Marsh Nutrient Offset provisions. It is noted that single daily nitrogen capture figures are quoted in the Stage 3 Assessment for the Mangrove Offset Area (MOA) but any uncertainty attending these figures is not discussed. It is recognised that the approach is 'new and innovative' and that a margin of safety is built in - but protection of water quality in the estuary hinges upon the ongoing function of that offset.	The extensive assessments carried out towards the design of the MOA (as evidenced in this document and other supporting documents) have assumed a conservative factor of safety. It is understood that with the concept behind the MOA being novel, a certain level of uncertainty is expected. However, in order to demonstrate that the concept is robust and viable, Water Technology and Lendlease are currently in discussions with Griffith University (Dr. Fernanada Adame) regarding the possibility of a long-term (5 year) ARC Linkage research based monitoring program for the project (noting that if the ARC Linkage submission is unsuccessful that a comparable, though almost certainly smaller, scientific research and validation program will still take place). The monitoring program will include several aspects including studies of the establishment of the marine plants and associated water quality and hydrological aspects. It is also expected to cover the following: ■ Measurements of marine plants (e.g. percent coverage); ■ Monitoring of growth rates; and ■ Measurement of nutrient assimilation rates to establish the intended fuction of the MOA. It is also noted that several potential key pollutant removal 'pathways' were deliberately not included in the analysis to provide even further factors of safety (e.g. removals in the sediment forebay, losses due to salt marsh uptake). These processes will however be included in the ARC Linkage (or equivalent) assessments

Item	DAF Comments	Watertech Response
Agriculture	In regards to reference papers quoted, it is noted that the wetland studied by Dr Adame et al was a paperbark swamp up north and it consumes nitrate - which aquaculture doesn't emit to any great extent. So the scheme can't apply directly to aquaculture.	The implication of this statement is not clear. The reference list contains articles that have been referred to for general guidance and as supporting information based on our discussions with experts in the field. The MOA is intended to offset nutrients loads in the recycled water produced by the proposed SRBWWTP. The SRBWWTP is not intended to offset nutrient loads arising from local aquaculture practices.
Biodiversity (Waterways providing for fish passage)	It is stated that an ancillary benefit of the MOA will be provision of fish habitat. Fish passage into and through the MOA habitats should not compromise the health, productivity, marketability or suitability for human consumption of fish. If passage into the MOA is proposed, include the following information: ■ Detail how abiotic conditions within the drain are suitable for fish.	Questions raised regarding the provision of fish habitat and fish passage have been addressed in reponses provided by Saunders Havill Group. The abiotic[13] conditions within the drain and the MOA will be consistant with those of the Logan River. Any changes in such abiotic conditions are considerably negligible. This is evidenced in the assessments detailed in Sections 9, 10 and 11 of this report. The design process for the MOA emphasises the maintenance of abiotic conditions in consistency with the Logan River as this is vital for the establishment and rehabilitation of mangroves within the MOA.

[13] An abiotic factor is a non-living component in the environment, which can either be a chemical or physical presence. Abiotic factors fall into three basic categories: climatic (includes rainfall, sunlight, weather, humidity, etc.), edaphic (includes soil and geography of the land) and social (includes how the land and water resources in the area are being used). Common abiotic factors are atmosphere, chemical elements, sunlight/temperature, wind and water.

Item	DAF Comments	Watertech Response
Marine Plants	As specified in the Appendix I – Letter from Dr Maria Fernanda Adame in the Report, Water Technology dated 18 September 2020, a monitoring program to follow up on the establishment of the marine plants and the adequacy of the hydrology throughout the MOA is important to include in the project. This should include quantifiable measurements of marine plants (e.g. percent coverage) at identified times (e.g. annually) to ensure success of the MOA is on track. In addition, the monitoring program should include alert to actions and reporting requirements to ensure the proposed MOA establishes and functions as intended. Include a monitoring program that reflects the above in the project and provide details in the application.	As mentioned in one of our responses above, Water Technology and Lendlease are currently in discussions with Griffith University (Dr. Fernanada Adame) regarding the possibility of a long-term research based monitoring program for the project. The monitoring program is expected to include several aspects including the establishment of the marine plants and associated water quality and hydrological aspects. It is also expected to cover the following: ■ Measurements of marine plants (e.g. percent coverage); ■ Monitoring of growth rates; and ■ Measurement of nutrient assimilation rates to establish the intended fuction of the MOA.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

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WATER TECHNOLOGY
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APPENDIX A
KNOWN CASES OF MANGROVE RESTORATION AND REHABILITATION



Documented mangrove restoration or rehabilitation projects (Derived from J. López-Portillo et al. 2017). Examples highlighted in green involved some form of hydrologic/hydraulic modifications such as excavations, construction of outlets and channels, etc.

Biogeographic region	Project site/country	Cause of impairment	Amelioration procedure
Atlantic-East-Pacific (AEP)	Windstar, Florida, USA	Dredge spoil blocked normal tidal flushing	Hydrologic restoration by restoring elevation, Forestation
	West Lake, Florida, USA	Filled wetlands	Excavation of historical fill in mangroves, hydrologic restoration, no planting of mangroves
	Florida East Coast, USA	Diked wetlands for mosquito control	Dredged deposits removed, diked mosquito control impoundments breached, very little forestation, natural recovery predominantly
	Rookery Bay, Florida, USA	Incomplete tidal flushing, elevated salinity, waterlogging	Restoring original elevation, excavation of water outlets; Forestation
	Bahía de Navachiste, Sinaloa, Mexico	Accumulation of dredging spoils	Channel digging on dredge material terraces and afforestation of nursery plants
	Laguna Balandra, Baja California, Mexico	Deforestation	Forestation, natural regeneration
	Laguna de Enfermería, Baja California, Mexico	Block of feeder channel by road	Hydrologic restoration, natural regeneration
	El Mogote, Baja California, Mexico	Hurricane-caused blocking of outlet with a sand dune	Hydrologic restoration
	Huizache-Caimanero, Sinaloa, Mexico	Accumulation of dredging spoils	Forestation with nursery plants
	Laguna Nichupté, Quintana Roo, Mexico	Hurricane damage, probably including blocking water outlets	Afforestation, Hydrologic restoration
	Tampamachoco, Veracruz, Mexico	Water flow obstruction by power line embankments	Hydrologic restoration
	Yucatán Peninsula, Mexico	Water flow obstruction by closure of inlets after a strong hurricane	Hydraulic restoration and planting from nursery
	Celestún, Yucatán, Mexico	Water flow obstruction by closure of inlets and road construction	Hydraulic restoration and planting from nursery
	Términos Lagoon, Campeche, Mexico	Water flow obstruction by closure of inlets after a strong hurricane	Hydraulic restoration and planting from nursery

Biogeographic region	Project site/country	Cause of impairment	Amelioration procedure
	Jaina, Petenes BR, Campeche, Mexico.	Water flow obstruction by closure of inlets and road construction	Hydraulic restoration and planting with propagules
	Isla Arena, Campeche, Mexico	Water flow obstruction by closure of inlets after a strong hurricane	Hydraulic restoration and planting from nursery
	Laguna de Cabildo, Chiapas, Mexico	Channel excavation and obstruction of water by bunds	Direct seeding of propagules and nursery plants
	Laguna de Pozuelos, Chiapas, Mexico	Channel excavation and obstruction of water by bunds	Direct seeding of R. mangle propagules and nursery plants
	Barra del Río Cahoacán, Mexico	Siltation from upland erosion	Direct sowing of collected propagules and nursery plants
	Punta Galeta, Panama	Deforestation (?), invasion by Saccharum spontaneous	Forestation
	Ciénaga Grande de Santa Marta, Colombia	Interruption of major water flows by road construction	Hydraulic restoration, forestation
	Parque Nacional Corales del Rosario, Colombia	Unspecified	Seeding and forestation with R. mangle
	Two sites, Puerto Rico	Hurricane effects	Natural regeneration by recolonization of L. racemosa
	Martin Peña Channel, San Juan, Puerto Rico	Urban detritus and siltation, deforestation	Urban renewal, removal of debris, no planting, just natural recolonization
	Ajuruteua Peninsula, Bragança, Brazil	Disturbance of hydrological regime by road construction	Natural regeneration by recolonization of A. germinans
	Río Jaguaribe, Rio Grande do Norte, Brazil	Deforestation	Seeding and forestation with R. mangle
	Río las Ostras, Río de Janeiro, Brazil	Deforestation	Forestation and natural regeneration
	Baixada Santista, Estuário de Santos, Río Cubatão, Brazil	Deforestation, pollution, dredging	Planting seeds and propagules
Indo-West-Pacific (IWP)	Shenzhen Bay, China	Urban encroachment and pollution, increase in siltation rates	Restoration plan including integration of rustic shrimp ponds (gei wei) and mangrove species communities

Biogeographic region	Project site/country	Cause of impairment	Amelioration procedure
	Qi'ao Reserve, China	Deforestation	Seeding
	Barisal, Chitta Gong, Patuakhali, Noakhali, Bangladesh	Newly accreting mudflats	Afforestation
	Pichavaram, Tamil Nadu, India	Extensive deforestation, soil collapse	Hydraulic rehabilitation by excavating main and secondary channels, forestation
	Nellore, Andhra Pradesh, India	Exposed shores after tsunami or cyclones	Forestation with upland dune plants and some mangroves but no distinction is made between the two at all 18 sites
	Prakasam, Andhra Pradesh, India	Exposed shores after tsunami or cyclones	Forestation
	Guntur, Andhra Pradesh, India	Exposed shores after tsunami or cyclones	Forestation
	Krishna, Andhra Pradesh, India	Exposed shores after tsunami or cyclones	Forestation
	West Godavari, Andhra Pradesh, India	Exposed shores after tsunami or cyclones	Forestation
	East Godavari, Andhra Pradesh, India	Exposed shores after tsunami or cyclones	Forestation
	Visakhapatnam, Andhra Pradesh, India	Exposed shores after tsunami or cyclones	Forestation
	Pulicat Lake, Andhra Pradesh/Tamil Nadu, India		Planting from nursery
	Kannur, Kerala, India	Exposed shores after tsunami or cyclones	Forestation
	Kasargod, Kerala, India	Exposed shores after tsunami or cyclones	Forestation
	Thiruvallur, Tamil Nadu, India	Exposed shores after tsunami or cyclones	Forestation
	Kanchipuram, Tamil Nadu, India	Exposed shores after tsunami or cyclones	Forestation
	Nagapattinam, Tamil Nadu, India	Exposed shores after tsunami or cyclones	Forestation
	Thiruvarur, Tamil Nadu, India	Exposed shores after tsunami or cyclones	Forestation
	Thanjavur, Tamil Nadu, India	Exposed shores after tsunami or cyclones	Forestation
	Pudukottai, Tamil Nadu, India	Exposed shores after tsunami or cyclones	Forestation

Biogeographic region	Project site/country	Cause of impairment	Amelioration procedure
	Ramanathapuram, Tamil Nadu, India	Exposed shores after tsunami or cyclones	Forestation
	Tutic, Tamil Nadu, India	Exposed shores after tsunami or cyclones	Forestation
	Tirunelveli/Kanyakumari, Tamil Nadu, India	Exposed shores after tsunami or cyclones	Forestation
	Trapaing Sangke, Cambodia		Planting from nursery
	Kien Giang, Cambodia	Exposure to wave action and erosion	Construction of Melaleuca fence and mangrove planting
	Andaman Coast, Thailand		Hydraulic restoration and planting from nursery
	Klong Gnao, Thailand	Wood harvesting, tin mining, aquaculture	Planting of propagules and plants
	Philippines	Fish/shrimp culture ponds	Multispecies planting
	Thong Nian, Thailand	Shrimp culture ponds	breaching of banks to rehabilitate water flow, planting of propagules and plants
	Bolgoda Lake, Sri Lanka		Planting from nursery
	Madampe Lake, Sri Lanka		Planting from nursery
	Pambala-Chilaw lagoon, Sri Lanka	Shrimp aquaculture pond	Remote sensing update, forestation
	North Sumatra, Aceh Besar, Lhok Nga, Indonesia	Deforestation and erosion due to tsunami	Planting?
	Banda Aceh, North Sumatra, Indonesia	Deforestation and erosion due to tsunami	Planting?
	Tanakeke Island, Sulawesi, Indonesia	Shrimp aquaculture pond	Hydrologic restoration of an abandoned shrimp aquaculture pond area followed by limited planting
	Jaring Halus, NE Langkat Wildlife Sanctuary, North Sumatera Province, Sumatra	Shrimp aquaculture pond	Hydrologic restoration in 10 ha of an abandoned shrimp aquaculture pond area followed by limited planting
	Tiwoho Village, North Sulawesi	Shrimp aquaculture pond	Hydrologic restoration in 25 ha of an abandoned shrimp aquaculture pond area followed by limited planting

Biogeographic region	Project site/country	Cause of impairment	Amelioration procedure
	Sungai Haji Dorani, Malaysia	Exposed shoreline	Breakwater construction to induce natural establishment of A. marina
	Sungai Haji Dorani, Malaysia	Exposed shoreline	Break water, transplant, natural regeneration
	Sabah, northern Borneo, Malaysia	Areas encroached by oil palms (7 sites) or shrimp ponds (2 sites); five sites are deforested	Forestation in 14 project sites located in five mangrove forest reserves. Additional hydrologic restoration in areas encroached by oil palms (7 sites) or shrimp ponds (2 sites)
	Cabrousse, Senegal	Deforestation, blockage of water flows, droughts	Seeding (propagule planting)
	Kiunga Marine National Reserve, Kenya	Deforestation, silting	Natural regeneration
	Mida Creek, Kenya	Deforestation, silting	Natural regeneration
	Tudor Creek, Kenya	Deforestation, silting	Natural regeneration
	Gazi Bay and Mwache Creek, Kenya	Deforestation, silting	Natural regeneration
	Gazi, Kenya	Deforestation, silting	Forestation
	Mamelo Honko, Madagascar	Deforestation	Seeding (Propagule planting)
	Ranongga, Salomon Islands, Melanesia	Deforestation	Replanting to replace vegetation lost after an earthquake
	Brisbane International Airport, Australia	Filling of main creek and excavation of other channels	Hydrologic restoration by channel digging and forestation

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APPENDIX B BASELINE WATER QUALITY - PART A: METALS AND TRACE ELEMENTS



Metals and Trace Elements (Totals)

Parameter	Unit	Upper Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (High Tide)	Adjacent (Low Tide)	Lower Reach (High Tide)	Lower Reach (Low Tide)	Trigger values for marine water (µg/L) – For 95% species protection*	Low reliability trigger values*	Toxicant guidelines for the protection of aquaculture species (saltwater)
Aluminium	mg/L	0.31	0.25	0.26	0.21	0.25	0.18	ID	0.0005	<0.01
Arsenic	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	ID	0.0023 (As III), 0.0045 (As(V)	<0.03
Cadmium	mg/L	<0.0008	<0.0008	<0.0008	<0.0008	<0.0008	<0.0008	0.0055		<0.0005 – 0.005 (varies with hardness)
Calcium	mg/L	340	248	362	263	375	284	-		-
Chromium	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.004		<0.02
Copper	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.0013		<0.005
Iron	mg/L	0.4	0.34	0.33	0.27	0.31	0.23	ID	0.3	<0.01
Lead	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.0044		<0.001 – 0.007 (varies with hardness)
Magnesium	mg/L	1030	740	1130	790	1170	860	ID		ID
Manganese	mg/L	0.021	0.03	0.017	0.025	0.016	0.022	ID	<0.01	<0.01
Mercury	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	Values are for Mercury (inorganic), 0.1 µg/L is recommended.	<1
Nickel	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.07		<0.1
Potassium	mg/L	340	240	370	260	390	280	-		-

Parameter	Unit	Upper Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (High Tide)	Adjacent (Low Tide)	Lower Reach (High Tide)	Lower Reach (Low Tide)	Trigger values for marine water (µg/L) – For 95% species protection*	Low reliability trigger values*	Toxicant guidelines for the protection of aquaculture species (saltwater)
Sodium	mg/L	8200	5810	8890	6290	9230	6770	-		-
Sulphur as SO4	mg/L	2230	1570	2340	1690	2400	1780	-		-
Tin	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	ID	Not prescribed	-
Zinc	mg/L	0.0085	0.0045	<0.004	<0.004	<0.004	0.0091	0.015		<0.005

- *WQOs for moderately disturbed aquatic ecosystems in the Logan River (mid estuary)
- ID = Insufficient Data
- For parameters with insufficient data, low reliability marine guideline trigger values are indicated in the comments section. These are indications only and are not recommended values as per ANZECC 2018 guidelines. See https://www.waterquality.gov.au/anz-guidelines/resources/previous-guidelines/anzecc-armcanz-2000 for details.

ANZECC 2018 toxicant guidelines for the protection of aquaculture species (cultured fish, molluscs and crustaceans) are derived from Table 4.4.3 in Chapter 4 (Primary Industries) in ANZECC 2000 guidelines.

Metals and Trace Elements (Soluble)

Parameter	Unit	Upper Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (High Tide)	Adjacent (Low Tide)	Lower Reach (High Tide)	Lower Reach (Low Tide)	Trigger values for marine water (µg/L) – For 95% species protection*	Low reliability trigger values*	Toxicant guidelines for the protection of aquaculture species (saltwater)
Aluminium	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	ID	0.0005	<0.01
Arsenic	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	ID	0.0023 (As III), 0.0045 (As(V)	<0.03

Parameter	Unit	Upper Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (High Tide)	Adjacent (Low Tide)	Lower Reach (High Tide)	Lower Reach (Low Tide)	Trigger values for marine water (µg/L) – For 95% species protection*	Low reliability trigger values*	Toxicant guidelines for the protection of aquaculture species (saltwater)
Cadmium	mg/L	<0.0008	<0.0008	<0.0008	<0.0008	<0.0008	<0.0008	0.0055		<0.0005 – 0.005 (varies with hardness)
Calcium	mg/L	333	244	360	271	376	278	-		-
Chromium	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.004		<0.02
Copper	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.0013		<0.005
Iron	mg/L	<0.004	0.0044	<0.004	<0.004	<0.004	<0.004	ID	0.3	<0.01
Lead	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.0044		<0.001 – 0.007 (varies with hardness)
Magnesium	mg/L	1040	732	1120	787	1160	845	ID		ID
Manganese	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	ID	<0.01	<0.01
Mercury	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	Values are for Mercury (inorganic), 0.1 µg/L is recommended.	<1
Nickel	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.07		<0.1
Potassium	mg/L	350	240	380	270	390	280	-		-
Sodium	mg/L	8210	5650	8940	6210	9330	6560	-		-
Sulphur as SO4	mg/L	2200	1510	2350	1670	2430	1770	-		-
Tin	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	ID	Not prescribed	-

Parameter	Unit	Upper Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (High Tide)	Adjacent (Low Tide)	Lower Reach (High Tide)	Lower Reach (Low Tide)	Trigger values for marine water (µg/L) – For 95% species protection*	Low reliability trigger values*	Toxicant guidelines for the protection of aquaculture species (saltwater)
Zinc	mg/L	0.006	<0.004	<0.004	<0.004	<0.004	0.01	0.015		<0.005

- *WQOs for moderately disturbed aquatic ecosystems in the Logan River (mid estuary)
- ID = Insufficient Data
- For parameters with insufficient data, low reliability marine guideline trigger values are indicated in the comments section. These are indications only and are not recommended values as per ANZECC 2018 guidelines. See https://www.waterquality.gov.au/anz-guidelines/resources/previous-guidelines/anzecc-armcanz-2000 for details.
- ANZECC 2018 toxicant guidelines for the protection of aquaculture species (cultured fish, molluscs and crustaceans) are derived from Table 4.4.3 in Chapter 4 (Primary Industries) in ANZECC 2000 guidelines.

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APPENDIX C
BASELINE WATER QUALITY - PART B: PHARMACEUTICALS AND PPCPS



Analyte	Unit	Reporting Limit	Upper Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (High Tide)	Adjacent (Low Tide)	Lower Reach (High Tide)	Lower Reach (Low Tide)	Guideline Value*
Acesulfame K (sweetener)	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	--
Alprazolam	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.2
Amidotrizoate (sodium)	µg/L	0.2	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	--
Amitriptyline	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	--
Atenolol	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	20
Atorvastatin	µg/L	0.02	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	2.3
Baclofen	µg/L	0.02	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	--
Betaxolol	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	10
Caffeine	µg/L	0.02	1.7	1.2	0.9	0.6	0.9	1.2	--
Carbamazepine	µg/L	0.02	< 0.02	0.05	< 0.02	0.04	< 0.02	0.04	100
Cefalexin	µg/L	0.5	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	40
Chloramphenicol	µg/L	0.02	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	200
Citalopram	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	10
Codeine	µg/L	0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	50
Cyclophosphamide	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	4
Dapsone	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	--
Desmethyl Citalopram	µg/L	0.02	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	10
Desmethyl Diazepam	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2
Diazepam	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2

Analyte	Unit	Reporting Limit	Upper Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (High Tide)	Adjacent (Low Tide)	Lower Reach (High Tide)	Lower Reach (Low Tide)	Guideline Value*
Diclofenac	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2
Diethyltoluamide	µg/L	0.02	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2000
Diphenhydramine	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	--
Doxepin	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	--
Doxylamine	µg/L	0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	--
Erythromycin anhydrate	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	20
Fluoxetine	µg/L	0.2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	10
Fluvastatin	µg/L	0.02	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	--
Furosemide	µg/L	0.02	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	10
Gabapentin	µg/L	0.02	< 0.02	0.03	< 0.02	0.02	< 0.02	0.02	--
Gemfibrozol	µg/L	0.02	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	600
Hydrochlorthiazide	µg/L	0.02	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	10
Ibuprofen	µg/L	0.5	NA	NA	NA	NA	NA	NA	400
Ifosfamide	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	4
Indomethacin	µg/L	0.02	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	20
Iopromide	µg/L	0.05	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	800
Lincomycin	µg/L	0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	4000
Methadone	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	--
Methamphetamine	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	--
Metoprolol	µg/L	0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	20

Analyte	Unit	Reporting Limit	Upper Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (High Tide)	Adjacent (Low Tide)	Lower Reach (High Tide)	Lower Reach (Low Tide)	Guideline Value*
Mirtazapine	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	--
Naproxen	µg/L	0.02	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	200
Oxazepam	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	20
Oxycodone	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	10
Paracetamol	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	200
Pethidine	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	--
Pheniramine	µg/L	0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	--
Phenytoin	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	--
Pholcodine	µg/L	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	--
Praziquantel	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	70
Primidone	µg/L	0.02	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	--
Propranolol	µg/L	0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	40
Pseudoephedrine	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	--
Ranitidine	µg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	80
Roxithromycin	µg/L	0.02	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	200
Salicylic acid	µg/L	0.05	0.6	< 0.2	0.2	0.2	< 0.2	< 0.2	100
Sertraline	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	--
Simvastatin	µg/L	0.5	NA	NA	NA	NA	NA	NA	--
Sulfadiazine	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1000
Sulfamethoxazole	µg/L	0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	200

Analyte	Unit	Reporting Limit	Upper Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (High Tide)	Adjacent (Low Tide)	Lower Reach (High Tide)	Lower Reach (Low Tide)	Guideline Value*
Sulfasalazine	µg/L	0.05	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	500
Sulfathiazole	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	40
Temazepam	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	5
Theophylline	µg/L	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	200
Tramadol	µg/L	0.02	< 0.02	0.03	< 0.02	0.02	< 0.02	0.02	--
Triclosan	µg/L	0.2	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1000
Trimethoprim	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	70
Tylosin	µg/L	0.02	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1000
Venlafaxine	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	40
Warfarin	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1
	*All available guideline values are Public Health Regulation Standard Guidelines								

Other Compounds

Other Compounds	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	Guideline Value
Benzenesulfonanilide	µg/L	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	-
1H-Benzotriazole	µg/L	0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	-
1H-Benzotriazole, 1-methyl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
1H-Benzotriazole, 4-methyl	µg/L	0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	-

Other Compounds	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	Guideline Value
1 H-Benzotriazole, 5-methyl	µg/L	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	-
2-Benzyl-4-chlorophenol	µg/L	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	-
4-Chloro-3,5-dimethylphenol	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
2,4-Di-t-butylphenol	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
2,6-Di-t-butylphenol	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
2,6-Di-t-butyl-p-cresol (BHT)	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
Galaxolide	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
Icaridin	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
Moclobemide	µg/L	1	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9	-
Musk Ketone	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
Musk Xylene	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
N-Butylbenzenesulfonamide	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
N-Butyltoluenesulfonamide	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
Tonalid	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
Triclosan	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
Triclosan methyl ether	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
Tri-n-butyl phosphate	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
Triethyl phosphate	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
Tris(chloroethyl) phosphate	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-

Other Compounds	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	Guideline Value
Tris(chloropropyl) phosphate isomers	µg/L	0.1	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	-
Tris(dichloropropyl) phosphate	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-

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APPENDIX D
BASELINE WATER QUALITY – PART C: ENDOCRINE DISRUPTING COMPOUNDS



Endocrine Disrupting Compounds (EDC)	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	Public Health Reg. Std.
4-t-Octylphenol	ng/L	10	< 85	< 81	< 96	< 85	< 87	< 85	50000
Nonylphenol	ng/L	50	< 420	< 400	< 480	< 420	< 430	< 430	500000
Bisphenol A	ng/L	10	< 85	< 81	< 96	< 85	< 87	< 85	200000
Estrone	ng/L	1	< 9	< 8	< 10	< 9	< 9	< 9	30
17β-Estradiol	ng/L	2	< 17	< 16	< 19	< 17	< 17	< 17	200
Estriol	ng/L	2	< 17	< 16	< 19	< 17	< 17	< 17	50
17α-Ethynylestradiol	ng/L	2	< 17	< 16	< 19	< 17	< 17	< 17	2
Norgestrel	ng/L	2	< 17	< 16	< 19	< 17	< 17	< 17	
Testosterone	ng/L	5	< 42	< 40	< 48	< 42	< 43	< 43	7000
Androsterone	ng/L	5	< 17	< 16	< 19	< 17	< 17	< 17	10000
Etiocholanolone	ng/L	5	< 42	< 40	< 48	< 42	< 43	< 43	
Cholesterol (not an EDC)	ng/L	50	< 420	< 400	< 480	< 420	< 430	< 430	
Equilenin	ng/L	2	< 17	< 16	< 19	< 17	< 17	< 17	30
Equilin	ng/L	2	< 17	< 16	< 19	< 17	< 17	< 17	30
Mestranol	ng/L	5	< 42	< 40	< 48	< 42	< 43	< 43	2
Cumylphenol	ng/L	10	< 85	< 81	< 96	< 85	< 87	< 85	
17α-Estradiol	ng/L	2	< 17	< 16	< 19	< 17	< 17	< 17	200
Norethindrone	ng/L	2	< 17	< 16	< 19	< 17	< 17	< 17	200
Progesterone	ng/L	20	< 170	< 160	< 190	< 170	< 170	< 170	100000

Endocrine Disrupting Compounds (EDC)	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	Public Health Reg. Std.
Androstenedione	ng/L	5	< 42	< 40	< 48	< 42	< 43	< 43	
Dihydrotestosterone	ng/L	5	< 42	< 40	< 48	< 42	< 43	< 43	
β-Trenbolone	ng/L	7	< 59	< 56	< 67	< 59	< 61	< 60	
Predicted estradiol equivalent	ng/L	2	< 17	< 16	< 19	< 17	< 17	< 17	
2-Nitro-m-xylene	%		76	80	79	76	86	78	
Dibromobiphenyl	%		97	111	112	107	118	116	
Pyrene-d10	%		107	116	110	107	115	112	
Triphenyl phosphate	%		94	104	98	101	104	104	
Decachlorobiphenyl	%		96	95	85	87	87	84	

WATER TECHNOLOGY
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APPENDIX E
BASELINE WATER QUALITY – PART D: HERBICIDES



Herbicides by GCMS

Herbicides by GCMS	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value
Ametryn	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	70
Amitraz	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	9
Atrazine	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	20
Bromacil	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	400
Desethyl Atrazine	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Desisopropyl Atrazine	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
3,4-Dichloroaniline	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Diclofop-methyl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	5
Fluazifop-butyl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Fluometuron	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	70
Haloxyfop-2-etotyl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	1
Haloxyfop-methyl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	1
Hexazinone	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	400
Metolachlor	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	300
Metribuzin	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	70
Molinate	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	4
Oxyfluorfen	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Pendimethalin	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	400

Herbicides by GCMS	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value
Prometryn	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Propanil	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	700
Propazine	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	50
Simazine	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	20
Tebuthiuron	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Tebuthylazine	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	10
Terbutryn	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	400
Triallate	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Trifuralin	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	90

Herbicides in water (by Direct Injection LCMSMS Method)

Herbicides in water by Direct Injection LCMSMS	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value
2,4-D	µg/L	0.02	**0.04**	**0.03**	**0.02**	**0.05**	**0.04**	**0.05**	30
2,4-DB	µg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
2,4-DP (Dichlorprop)	µg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	100
2,4,5-T	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	100
3,4-Dichloroaniline	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Acetamiprid	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	

Herbicides in water by Direct Injection LCMSMS	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value
Acifluorfen	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Ametryn	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	70
Amicarbazone	µg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Asulam	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	70
Atrazine	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	20
Atrazine, 2-hydroxy	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Bromacil	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	400
Bromoxynil	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	10
Chlorpyrifos	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	10
Chlorpyrifos oxon	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Clomazone	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Clothianidin	µg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Cyanazine	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Dalapon (2,2-DPA)	µg/L	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	500
DCPMU	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
DCPU	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Desethyl Atrazine	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Desisopropyl Atrazine	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Diazinon	µg/L	0.01	< 0.01	< 0.01	< 0.01	**0.02**	< 0.01	< 0.01	4

Herbicides in water by Direct Injection LCMSMS	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value
Dicamba	µg/L	0.05	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	100
Dinotefuran	µg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Diuron	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	20
Ethametsulfuron methyl	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Ethoxysulfuron	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Fipronil	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.7
Fipronil Desulfinyl	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.7
Fipronil sulfide	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.7
Fipronil sulfone	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.7
Flamprop -methyl	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4
Fluazifop (acid)	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Fluometuron	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	70
Fluroxypyr	µg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Flusilazole	µg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Flutriafol	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Halosulfuron methyl	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Haloxyfop (acid)	µg/L	0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1
Hexazinone	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	400
Imazapic	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	

Herbicides in water by Direct Injection LCMSMS	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value
Imazapyr	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	9000
Imazethaphyr	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Imidacloprid	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Imidacloprid metabolites	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Ioxynil	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Isoxaflutole metabolite (DKN)	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
MCPA	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	40
MCPB	µg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Mecoprop	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Mesosulfuron methyl	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Methoxyfenozide	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Metolachlor	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	300
Metolachlor-OXA	µg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Metribuzin	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	70
Metsulfuron methyl	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	40
Molinate	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	4
Napropamide	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	400
N-Desmethyl Acetampiprid	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Pendimethalin	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	400

Herbicides in water by Direct Injection LCMSMS	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value
Picloram	µg/L	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	300
Prometryn	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Propachlor	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	70
Propazin-2-hydroxy	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Propoxur	µg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Sethoxydim	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Simazine	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	20
Sulfosulfuron	µg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Tebuthiuron	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Terbuthylazine	µg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	10
Terbuthylazine desethyl	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Terbutryn	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	400
Thiacloprid	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Thiamethoxam	µg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Total Acetamiprid	µg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	20
Total Diuron	µg/L	0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	20
Total Fipronil	µg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.7
Total Imidacloprid	µg/L	0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	
Triclopyr	µg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	20

Herbicides in water by Direct Injection LCMSMS	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value
Trifloxysulfuron	µg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Trinexapac (acid)	µg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	

R01v05_20200099_Southern_Redland_Bay_Stage_3_Assessments

WATER TECHNOLOGY
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APPENDIX F
BASELINE WATER QUALITY – PART E: PESTICIDES



Organochlorine Pesticides

Organochlorine Pesticides	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value*
Aldrin	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	0.3
Dieldrin	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	0.3
Total Aldrin & Dieldrin	µg/L	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.3
Chlordane cis	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	2
Chlordane trans	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	2
Total Chlordane	µg/L	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2
Chlordene	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Chlordene epoxide	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Chlordene-1-hydroxy	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Chlordene-1-hydro -2,3-e12oxide	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
DDD (pp)	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	9
DDE (pp)	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	9
DDT (op)	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	9
DDT (pp)	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	9
Total DDT	µg/L	0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	9
DDD (op)	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
DDE (op)	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	

Organochlorine Pesticides	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value*
Total Dicofol	µg/L	1.5	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	4
α-Endosulfan	µg/L	0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	20
β-Endosulfan	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	20
Endosulfan sulfate	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	20
Total Endosulfan	µg/L	0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	20
Endosulfan ether	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Endosulfan lactone	µg/L	0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	.
Endrin	µg/L	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	
Endrin aldehyde	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
HCB	µg/L	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	
α-HCH	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
β-HCH	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
δ-HCH	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Heotachlor	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	0.3
Heptachlor epoxide	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	0.3
Total Heotachlor	µg/L	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.3
Lindane (γ-HCH)	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	10
Methoxychlor	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	300
Nonachlor cis	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	

Organochlorine Pesticides	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value*
Nonachlor trans	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Oxychlordane	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	2

Organophosphate Pesticides

Organophosphate Pesticides	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value
Azinphos-ethyl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Azinphos-methyl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	30
BromoQhos-ethyl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	10
Cadusafos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Carbophenothion	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	0.5
Chlorfenvinphos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	2
Chlorpyrifos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	10
Chlorpyrifos-methyl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Chlorpyrifos oxon	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Coumaphos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Demeton-O-methyl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Demeton-S	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Demeton-S-methyl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

Organophosphate Pesticides	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value
Diazinon	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	4
Dichlorvos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	5
Dimethoate	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	7
Omethoate	µg/L	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1
Total Dimethoate	µg/L	0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	7
Dioxathion	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Disulfoton	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	4
Ethion	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	4
Ethoprophos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	1
Etrimphos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Famphur	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Fenamiphos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	0.5
Fenchlorphos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Fenitrothion	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	7
Fenthion-ethyl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Fenthion (methyl)	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	7
Isofenphos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Malathion (Maldison)	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	70
Methidathion	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	6

Organophosphate Pesticides	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value
Mevinphos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	5
Monocrotophos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	2
Oxydemeton-methyl	µg/L	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	
Parathion (ethyl)	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	20
Parathion-methyl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	0.7
Phorate	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Phosmet	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Phosphamidon	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Pirimiphos-methyl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	90
Profenofos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	0.3
Prothiofos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Pyrazophos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	20
Sulprofos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	10
Temephos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	400
Terbufos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	0.9
Tetrachlorvinphos	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	100

Other Pesticides

Other Pesticides	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value
Benalaxyl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Bendiocarb	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Bitertanol	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Captan	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	400
Carbaryl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	30
DEET	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Dimethomorph	µg/L	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	
Fipronil	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	0.7
Flutriafol	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Furalaxyl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Metalaxyl	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Methoprene	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Oxadiazon	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Piperonyl butoxide	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	600
Pirimicarb	µg/L	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	7
Praziquantel	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Procymidone	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Propargite	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	7

Other Pesticides	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value
Propiconazole	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	100
Propoxur	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Rotenone	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Tebuconazole	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Tetradifon	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Thiabendazole	µg/L	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	
Triadimefon	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	90
Triadimenol	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Total Triadimefon	µg/L	0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	90
Vinclozolin	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	

Synthetic Pyrethroids (Insecticides)

Synthetic Pyrethroids	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value
Bifenthrin	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Bioresmethrin	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	100
Cyfluthrin	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	50
Cyhalothrin	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	

Synthetic Pyrethroids	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	ADWG Health Value
Cypermethrin	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	200
Deltamethrin	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	40
Fenvalerate	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	60
Fluvalinate	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Permethrin	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	200
Phenothrin	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Tetramethrin	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	
Transfluthrin	µg/L	0.1	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX G
BASELINE WATER QUALITY – PART F: PCBS



Polychlorinated Biphenyls (PCB)

Polychlorinated Biphenyls (PCB) (IUPAC Number and Congener Name)	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	Guideline Value
PCBs (Total)	µg/L	2	< 1.9	< 1.9	< 1.9	< 1.9	< 1.9	< 1.9	-
1 2-Chlorobi1 henyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
5 2,3-Dichlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
18 2,2',5-Trichlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
28+31 2,4,4'- + 2,4',5-Trichlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
44 2,2',3,5'-Tetrachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
52 2,2',5,5'-Tetrachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
66 2,3',4,4'-Tetrachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
77 3,3',4,4'-Tetrachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
81 3,4,4',5-Tetrachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
87 2,2',3,4,5'-Pentachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
101 2,2',4,5,5'-Pentachlorobiohenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
105 2,3,3',4,4'-Pentachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
110 2,3,3',4',6-Pentachlorobiohenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
114 2,3,4,4',5-Pentachlorobiohenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
118 2,3',4,4',5-Pentachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
123 2',3,4,4',5-Pentachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

Polychlorinated Biphenyls (PCB) (IUPAC Number and Congener Name)	Units	Reporting Limit	Upper Reach (High Tide)	Adjacent (High Tide)	Lower Reach (High Tide)	Upper Reach (Low Tide)	Adjacent (Low Tide)	Lower Reach (Low Tide)	Guideline Value
126 3,3',4,4',5-Pentachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
138 2,2',3,4,4',5'-Hexachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
141 2,2',3,4,5,5'-Hexachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
149 2,2',3,4',5',6-Hexachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
151 2,2',3,5,5',6-Hexachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
153 2,2',4,4',5,5'-Hexachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
156 2,3,3',4,4',5-Hexachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
157 2,3,3',4,4',5'-Hexachlorobiohenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
167 2,3',4,4',5,5'-Hexachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
169 3,3',4,4',5,5'-Hexachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
170 2,2'3,3'4,4'5-Heptachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
180 2,2'3,4,4'5,5'-Heptachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
183 2,2'3,4,4'5'6-Heotachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
189 2,3,3'4,4'5,5'-Heptachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
194 2,2'3,3'4,4'5,5'-Octachlorobiohenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-
206 2,2'3,3'4,4'5,5'6-Nonachlorobiphenyl	µg/L	0.10	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	-

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APPENDIX H
PROPOSED RECYCLED WATER EFFLUENT QUALITY



Maximum Reported Values for Parameters at another Southeast Queensland WWTP

Parameter	Units	Average Value	Maximum Value	Number of Samples	Beenyup WWTP Data
Electrical conductivity	µS/cm	1,643	1,940	23	-
Total dissolved solids	mg/L	954	1,170	23	-
Total Hardness as $CaCO_3$	mg/L	178	253	23	-
Bicarbonate Alkalinity as $CaCO_3$	mg/L	204	266	27	-
Total Alkalinity as $CaCO_3$	mg/L	204	266	27	-
Sulfate	mg/L	105	163	29	-
Chloride	mg/L	321	425	30	-
Calcium	mg/L	36	45	30	-
Magnesium	mg/L	22	34	27	-
Sodium	mg/L	270	378	27	-
Potassium	mg/L	27	38	30	-
Aluminium	mg/L	0.037	0.10	28	-
Arsenic	mg/L	0.0017	0.0030	28	-
Barium	mg/L	0.010	0.019	29	-
Cadmium	mg/L	0.00057	0.001	28	-
Chromium	mg/L	0.003	0.010	28	-
Cobalt	mg/L	0.0015	0.002	27	-
Copper	mg/L	0.0047	0.027	28	-
Iron	mg/L	0.17	0.25	28	-
Lead	mg/L	0.003	0.004	28	-
Lithium	mg/L	0.011	0.011	1	-
Manganese	mg/L	0.080	0.118	28	-
Molybdenum	mg/L	0.0016	0.006	28	-
Nickel	mg/L	0.0022	0.003	28	-
Silver	mg/L	0.001	0.001	28	-
Strontium	mg/L	0.26	0.31	29	-
Zinc	mg/L	0.055	0.26	29	-
Silica	mg/L	14.4	18.4	29	-
Total Cyanide	mg/L	0.035	0.113	28	-

Parameter	Units	Average Value	Maximum Value	Number of Samples	Beenyup WWTP Data
Fluoride	mg/L	0.55	1.8	29	-
Total Organic Carbon	mg/L	11.3	21	66	-
Anionic Surfactants as MBAS	mg/L	0.16	0.20	61	-
NDMA	ng/L	8	13	3	-
Bromide	mg/L	0.4	0.6	19	-
Chlorate	mg/L	0.1	0.8	5	-
EDTA	µg/L	146	186	2	210
Monocyclic Aromatic Hydrocarbons					
Toluene	µg/L	-	0.65	12	<2
Halogenated Aliphatic Compounds					
Chloromethane	µg/L	-	0.54	12	-
Tetrachloroethene	µg/L	-	1.78	12	<2
Halogenated Aromatic Compounds					
1.4-Dichlorobenzene	µg/L	-	0.34	12	<2
Trihalomethanes					
Chloroform	µg/L	-	2	12	0.33
Phenolic Compounds					
Hexachlorophene	µg/L	-	0.3	61	-
Phenol	µg/L	-	0.1	61	<0.01
Phenoxyacid Herbicides					
2,4-D	µg/L	-	0.03	2	0.07
Dalapon	µg/L	-	0.04	2	-
Dicamba	µg/L	-	0.29	2	<1.0
Mecoprop	µg/L	-	0.16	2	-
MCPA	µg/L	-	0.78	2	<0.1
Triclopyr	µg/L	-	0.02	2	<1.0
Radiological Compounds					
Gross Alpha	Bq/L	-	0.014	3	-
Gross Beta	Bq/L	-	0.53	3	-
Endocrine Disrupting Compounds					
Bisphenol A	ng/L	-	24	2	-
Nonylphenol	ng/L	-	86	2	-

Parameter	Units	Average Value	Maximum Value	Number of Samples	Beenyup WWTP Data
Pharmaceuticals					
Atenolol	µg/L	-	0.18	2	-
Caffeine	µg/L	-	0.04	2	-
Carbamazepine	µg/L	-	0.68	2	0.78
Citalopram	µg/L	-	0.15	2	-
Cyclophosphamide	µg/L	-	0.01	2	-
Desmethyl Citalopram	µg/L	-	0.06	2	-
Desmethyl Diazepam	µg/L	-	0.03	2	-
Diclofenac	µg/L	-	0.24	2	0.36
Doxylamine	µg/L	-	0.30	2	-
Erythromycin	µg/L	-	0.20	2	0.92
Fluoxetine	µg/L	-	0.01	2	-
Frusemide	µg/L	-	0.13	2	-
Gabapentin	µg/L	-	3	2	-
Gemfibrozol	µg/L	-	0.04	2	-
Hydrochlorthiadzide	µg/L	-	0.68	2	-
Indomethacin	µg/L	-	0.03	2	-
Lincomycin	µg/L	-	0.04	2	-
Metroprolol	µg/L	-	0.2	2	-
Naproxen	µg/L	-	0.16	2	0.39
Oxazepam	µg/L	-	1	2	-
Oxycodone	µg/L	-	0.03	2	-
Phentoin	µg/L	-	0.23	2	-
Praziquantel	µg/L	-	0.01	2	-
Propranolol	µg/L	-	0.04	2	-
Ranitidine	µg/L	-	0.22	2	-
Roxithromycin	µg/L	-	0.03	2	0.27
Salicylic acid	µg/L	-	0.03	2	<0.1
Sertraline	µg/L	-	0.02	2	-
Sulfsalazine	µg/L	-	0.28	2	-
Sulphamethoxazole	µg/L	-	0.53	2	-
Temazepam	µg/L	-	0.51	2	-
Tramadol	µg/L	-	0.63	2	-

Parameter	Units	Average Value	Maximum Value	Number of Samples	Beenyup WWTP Data
Triclosan	µg/L	-	0.02	2	-
Trimethoprim	µg/L	-	0.08	2	0.35
Venlafaxine	µg/L	-	1.18	2	-
Herbicides					
Ametryn	µg/L	-	0.04	2	<0.1
Atrazine	µg/L	-	0.02	2	<0.1
DEET	µg/L	-	0.19	2	-
Diazinon	µg/L	-	0.04	2	<0.1
Diuron	µg/L	-	0.22	2	<20
3,4 Dichloroaniline	µg/L	-	0.04	2	-
Propoxur	µg/L	-	0.08	2	<0.2
Simazine	µg/L	-	0.06	2	<0.1
Triclosan	µg/L	-	0.02	2	-

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

WATER TECHNOLOGY
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APPENDIX I
ACADEMIC ASSESSMENTS





Shiv Umapathi and Tony McAlistair
Water Technology
Water, Coastal and Environmental Consultants
South Brisbane, QLD Australia
12 September, 2019.

Re: Shoreline Mangrove Offset Program Due Diligence

I have review the report provided by Water Technology on the viability of creating a coastal wetland for the treatment of wastewater through nitrogen processing. The project is sound and based on the latest scientific research that shows that wetlands can improve water quality while providing a range of added benefits such as carbon sequestration, flooding mitigation, and increased biodiversity. The methodology to restore the wetlands are also in line with the best-practices for mangrove restoration, which have been shown to be successful in many regions around the world.

I have a few suggestions that could improve this project:

1- The mangroves can retain nitrogen not only through sediment accretion, but also through denitrification. Thus, this is an added removal rate that has not been considered for mangroves in this Report. According to my research, removal rates in mangroves are around 4 mg/m^2/h, which adds to the potential of these wetlands to remove nitrogen.
2- In mangrove forests some of the nitrate could be converted to ammonia through dissimilatory nitrate reduction (DNRA), which means that some of the nitrate that enters the wetlands will be transformed to ammonium.
3- Salinity of 25 ppt for the mangroves close to the freshwater outlet will not affect mangrove growth, in fact relatively low salinities (< 32 ppt) tend to favour mangrove growth.
4- Consider the inclusion of *Melaleuca quinquinervia* in the wetland. *Melaleuca* is a hardy species that grows relatively fast and has high denitrification rates (see Adame et al. 2019).
5- It would be important to include in the project a monitoring program to follow up on the establishment of the plants, the adequacy of the hydrology, and to ensure that the soil conditions are optimal for nitrogen removal (e.g. anaerobic, not anoxic).

If you have any further questions, please do not hesitate to contact me.

Kind regards,



Dr Maria Fernanda Adame

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September 12, 2019

Tony McAlister
Water Technology Pty Ltd
Level 3, 43 Peel Street
South Brisbane QLD 4101

Dear Tony

Re: Academic assessment of Shoreline Mangrove Offset Program Due Diligence

As requested, I have completed an assessment of the proposed Shoreline Mangrove Offset Program. I have focused on my primary area of expertise in greenhouse gas dynamics and provided additional comments around the nutrient and sediment components. Overall, this proposed program of works represents an exciting opportunity to minimize development impacts on receiving water bodies and demonstrates leadership in sustainability. The key to understanding the true value in such an exercise will be in monitoring key performance parameters over the project lifetime and demonstrating its value quantitatively.

Greenhouse gas emissions from the whole site should be monitored prior to project commencement, this data will be critical to understand the carbon benefits from coastal wetland establishment and greenhouse gas risk associated with the freshwater wetland. The inherent variability in emission rates across disturbed coastal sites means that literature values or the use of default rates will result in a potentially misleading estimate of true carbon benefits in this program. The proposed site has a number of ponds and ditches existing within it and these are known sources of greenhouse gas (in particular methane). The conversion of ponds and ditches to salt marsh and mangrove will greatly reduce methane emission rates as well as increase carbon sequestration rates as the colonization process progresses. The proposed freshwater wetland will likely be a strong greenhouse gas source of both methane and nitrous oxide, however, these emissions should balanced against the current emission rates from the pond that already exists within the proposed location. The net effect will likely be to convert this site from a greenhouse gas source to a strong greenhouse gas sink.

Baseline assessments of nutrient and sediment dynamics should consider the proximity of local sediment and nutrient sources such as the nearby aquaculture facility and Serpentine Creek. These local sources can significantly modify ambient levels and result in regulatory challenges if not identified prior to project commencement. Serpentine Creek generally has elevated total phosphorus and total suspended solids concentrations so outflows from this creek would likely increase the levels in waters adjacent the proposed site. Currently, the aquaculture facility does not appear operational, however, given the long-term nature of this offset program, the facility may be recommissioned and potentially increase nutrient loading in surrounding waters.

A number of specific comments are provided below:

Page 8 Line 42 “No planting of mangroves took place or was necessary” is an important finding. Recolonisation is a relatively slow process and efforts to accelerate this are both expensive and seldom result in long-term gains. Resources are likely better used creating optimal habitat as opposed to trying to force the colonization process.

Page 11 The figure legend for Figure 3-2 states the top panel is from 2010, this image appears to be taken prior to rehabilitation and should, therefore, be from approximately 10 years earlier.

Page 15 Section 3.1.2 Nutrient Removal Rates and Offsets. The key to quantifying these benefits will be to establish a comprehensive baseline prior to project commencement to track future changes in nutrient and carbon dynamics across the site.

Page 19 Line 7 This is critical to embed in the planning process, attempts to accelerate the colonization process through plantings should only be considered as a last resort. As noted in the case study review, there is little to be gained in accelerating the colonisation process if site preparation is appropriate.

Page 23 Line 1 – 4 This is correctly identified as an area of critical importance to the overall program success. There is a research opportunity to track the colonisation process and test the modelled predictions against long-term field measurements.

Page 27 Line 21 – 25 The site location on the outside of a river bend could result in relatively high water current velocities being experienced during major floods and be a major modifier of erosion rates. Although difficult to predict event frequency, the consequence is generally greatly increased erosion particularly on the outer bend of a river.

Page 27 Line 21 – 25 Consider in the disposal options that sediment delivery will allow the mangroves to persist as sea levels rise. Conceivably, part of the sediment disposal could be on site given the long-term nature of this program.

Page 36 Section 4.7.3 Sediment Forebay. Suspended sediment concentration and particle size distribution will be an important predictor of sediment settling rates in the forebay. Monitoring of concentration and particle size distribution during periods of no catchment inflows as well as during flow events will benefit management of the sediment forebay.

Page 37 Line 1 to 13 As stated there is a need to maintain sediment supply for continued mangrove health so this component will require careful management. The sediment forebay could also be particularly useful to reduce sediment delivery during major flood events. In addition, following major events it may be necessary to modify drainage across the whole mangrove and salt marsh area if large quantities of material is deposited.

In summary, I believe due diligence has been undertaken in development of this proposal and the proposed offset program is viable both in terms of nutrient polishing of discharge waters as well as carbon sequestration from the conversion of relatively degraded terrestrial habitat to mangrove and salt marsh. If successfully implemented, this program will signal a major shift in regional offset strategy and provide a sustainable pathway to minimizing environmental impacts of coastal developments.

Yours sincerely,



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APPENDIX J
GHD PEER REVIEW



Date updated		15/11/2019				
Relevant section/page	**Comments**		**GHD Response**	**Action**	**Responsibility**	**Status-Watertech update**
	Water Technology Memo from Tony McAlister					
Page 1, Section 1.2, First Paragraph	We assume this paragraph should say…consistent with Redland Water/Redland City Council policies.		noted.	amend ot include "policies and requirements"	GHD	n/a
Page 2, Section 1.3, First Dot Point –	The plant will intermittently bypass under heavy rainfall conditions. At such times, effluent quality will degrade somewhat, however with passage through the downstream system, no adverse impacts on the Logan River are likely from such short-term, intermittent, spikes of effluent. Similarly, dilution and nutrient processing and assimilation within the downstream system are expected to show no adverse impacts in these areas. Placement of bypasses directly into the mangrove area may be a logical action that has been discussed between Stantec and ourselves.		noted.	Water Tech to include a section in their report on the bypass once incorporateg GHD to update this section to reflect the change	Water tech GHD	Section 3.1.2.4 : "Sewage Bypass" added
Page 2, Section 1.4, Second Dot Point-	The modelling was conducted using an upgraded or modified version of the regularly peer-reviewed Healthy Land and Water receiving water quality model of the Logan River system. This model is used every year to inform the annual Report Card rating/grade for the Logan Estuary and Southern Moreton Bay. A copy of the most recently prepared report for the latest year's application can be provided to GHD if required. The 'pedigree' of this modelling is long, rigourous and thorough.		correction this refers to section 1.3 My suggestion to include an attachement explaining the modelling details still stands. Acknowledge receipt of the Healthy Land and Water model report	Water Tech to incorporate an attachment on the modelling as part of the Due Diligence. GHD to review and provide comment on the provided report.	Water tech GHD	Additional text added in section 4.7, HLW model will be attached to appendix E. All appendices are in folder: R:\Jobs\19020134_Shoreline_Mangrove_DD\Reporting\Appendices
Page 4, Section 2.2, Second Paragraph -	Use of the wording 'a decent site' is clumsy. Suggest rewording.		noted.	will reword	GHD	n/a
Page 4, Last Paragraph-	Sensitive receptors were not within the scope of the Water Technology review. These issues could be addressed in subsequent stages of the project.		noted.	will amend to mention that not assessed	GHD	n/a
Page 5, Section 2.3, Second Paragraph-	The literature review focused on mangroves as these are considered to be the dominant pathway and mechanism whereby nutrients will be assimilated by the proposed works. Also, saltmarsh communities will not necessarily be re-created or restored, rather existing areas of saltmarsh will be enhanced, as such this is a totally different matter. Also, in regard to this comment, all calculations relating to nutrient assimilation have only considered the impact of the proposed new mangrove areas. Any effects due to inundation of the enhanced salt marsh areas by larger tides will be additional to these effects.		the comment here related to the fact that we could not assess if these referenced projects were successful or not.	no action	Ghd to review if wording correctly represents WT comment.	n/a
Page 6, Section 2.4.1 –	The unidirectional gates, sediment forebay and access to tidal gates (noting the wording 'sediment forebays' is included twice in the GHD review) are primarily areas of cut, any excavated material will need to be tested for acid sulphate soils and appropriately limed if required. Remaining areas will not require treatment. We note that all other comments regarding acid sulphate soils are of interest and can/will be incorporated at the detailed design stage. None of these comments affect the underlying feasibility of the project. Where GHD comment that 'the plan is lacking a description of works in each area and the proposed levels of disturbance', this is considered acceptable as the design/concept is still conceptual in nature. When a more detailed and complete design is developed, more rigourous testing and management intervention planning will be warranted and able to occur. We also disagree with the groundwater comments as there are no beneficial uses of groundwater in the vicinity of the site and elevated groundwater levels are not expected to be of concern. This will however be confirmed as the detailed design process advances.		noted.	Amend sediment forebays to sediment forebay also check wording on 'the plan is lacking a description…' and amend	GHD	n/a
Page 9, Section 2.4.2 –	Erosion and sediment control considerations do not affect the viability of the concept, they are a detailed design issue which can be considered as the project design advances.		Erosion and sediment control was reviewed by GHD and found costs were not included in the KN Group estimate. Water Tech has deferred this to detailed design.	no action		n/a
Page 9, Section 2.4.3 –	We dislike the use of the word 'novel', which is used repeatedly within the document and has adverse connotations in our opinion. Similarly, the reference to 'more detailed revegetation strategies and long-term management plans' does not affect the due diligence nature of these assessments. Such matters can and will be required as the design evolves. Regarding the site preparation subsections, there will not be extended periods of standing water within the mangrove community, hence this discussion is irrelevant. Regarding natural versus active revegetation, we disagree that the report recommends active revegetation if this refers specifically to the mangroves. In fact, Stage 6 of the EMR protocol referenced in the report only recommends active revegetation after natural recruitment has been shown not to work. This misinterpretation affects subsequent GHD revegetation cost assessments.		noted on the word novel. Wrt inundation, will review response. Wrt natural vs active, noted.	amend the word "novel" review response amend response on active vs natural. GHD still believes that some active vegetation will need to be undertaken. This will not be changed.	GHD	n/a
Page 11, Species Selection –	- We disagree with GHD on the following comments: Mangroves readily grow in areas with elevated nutrients as evidenced by for example the inset image showing mangroves growing next to the Luggage Point sewage outfall. - The comment regarding the salinity of the effluent (25 PPT) is incorrect. The 'effluent' will be fresh (<0.3 PPT), whereas the salinity within the mangroves after full wastewater discharge occurs (>6 years after initial establishment) will typically be of the order of 25 PPT. This level of salinity, being approximately two thirds of seawater, is not 'low'.		will review. Check the tech reviewers appendix on mangroves		GHD	n/a
Page 12, Weed Management –	In our opinion, the presence of high levels of salinity in the mangrove forest should prevent weeds from establishing. This opinion is evidenced by the fact that there are viable mangrove forests all around Australia that do not require active weed management. Regardless, from a precautionary approach, we should allow for this matter to be reviewed at set periods and a provisional sum has been made in costings for any associated week management works.		noted. GHD to review wording around that.	no action	GHD	n/a
Page 13, Mosquito Management –	No water will stand on mangroves for more than five days; hence this is not of concern.		noted	no action		n/a
Page 13, Odour –	We question whether this is an issue as there are existing stands of mangroves along the Logan River, along Serpentine Creek and already in the eastern waterway on the site.		this has been raised as a potential odour problem. And should be covered in the DD repor to at least acknowledge it is a potential impact and that you have considered it.	Lendlease/watertech to confirm if section to be added in the DD report	Lendlease Water tech	A section (Section 4.5) has been added - Tony to add a few words (Also see line 37 in this excel sheet) - ADDRESSED
Page 19, Section 2.5.1 –	See earlier comment regarding provision of background modelling report.		noted			Addressed as per line 6 of this spreadsheet. Additional text added in section 4.7, HLW model will need to be attached to appendix E.

Relevant section/page	Comments	GHD Response	Action	Responsibility	Status-Watertech update
Page 14, Section 2.5.2,	First Dot Point – Flows into and out of the mangroves will be far smaller (approximately two orders of magnitude) than flows in the Logan River, hence this question is irrelevant.	GHD requested additional information on modelling. This can be in the form of a 5 page memo appended to the DD report providing model setup information. Water Tech has provided GHD with the South East Queensland – Receiving Waters Report 08 Logan Albert Healthy Land and Water Report Card Whilst this report refers to the whole logan river-mpreton bay model on which the shoreline mangrove project was modelled, the report does not provide information on the shoreline mangrove model setup. A technical memo appended to the DD report could include: a. The setup of the shoreline mangrove basin, including: i. Representation of the ground elevations within the basin ii. Manning's n roughness		Water Tech	This has been addressed in Section 4.8.2 that discusses the possible change in the tidal prism in the Logan Estuary
Page 14, Section 2.5.2, Second Dot Point –	Given the extremely low flow velocity within the mangrove forest, any impact of Mannings 'n' values on flow passage through the system will be trivial.	same as above		Water Tech	Section 4.7 (main) has been updated. A few lines and a missing figure were added.
Page 14, Section 2.5.2, Third Dot Point –	This statement is incorrect, and we do not understand where or how GHD reached this conclusion. The inlet and outlet will in fact be several submerged culverts and all tides will be able to interact with the basin. Mannings 'n' values in this case will make no difference to flows entering and leaving the basin.	same as above		Water Tech	n/a
	We are familiar with e-folding time analyses, however question how calculation of a residence time will relate to the due diligence nature of these assessments. The typical salinity value of 25 PPT shown by the modelling by inference indicates that the system has a reasonably long (several days at least) residence time, which is sufficient assessment in our opinion.	same as above		Water Tech	n/a
Section 2.5.4 –	None of these requests affect the due diligence nature of the study.		no action		n/a
Section 2.6.1 –	The floating wetland will not have 100% vegetated coverage as this would affect re-aeration and other key water quality related processes within the system. A typical coverage value of 30%was adopted to accommodate this issue. We also note that the performance of the freshwater wetland is not critical to the design of the system and its key role is to buffer flows, potentially provide for irrigation storage and at the same time remove some of the nutrients from the effluent. If in fact it does not perform as intended, there is ample capacity within the mangroves to remove any residual nutrients	noted. Will add more clarity on the overall objective of the freshwater. However this also needs to be highlighted in the DD report	GHD to add commentary on overall purpose of the FW wetland. Water Tech to amend/clarify the overall purpose of the FW wetland in the DD reprot	GHD Water tech	Addressed in Section 3.1.2.2 as per Tony's comments in column B.
Page 19 – Section 2.6.3 –	The bulk earthworks values are of a preliminary nature and to raise issues with this as has been done adds no value to the GHD review. Also, this is a capital cost issue for Lendlease to deal with and is not necessarily relevant to handover of this asset to Redland Council.	GHD scope is review of the DD report. Bulk earthworks volumes were checked against the estimate as part of this review. Water Tech has deferred this as a capital cost issue for Lendlease to resolve.	no action		n/a
Page 19 – Section 2.6.4 –	Any potential groundwater influences are expected be minimal. Once excavation works occur and tidal exchanges are initiated, the volume of water moving in and out of the basin will be far greater than any potential groundwater inflows. Over time, a new equilibrium condition will develop between the water level(s) in the mangroves and adjacent groundwater lenses such that any inflows will reduce over time.	Geotech review recommended groundwater and material won (cut) be assessed for constructability. Water Tech not concerned about long-term groundwater issues. No comments provided from a constructability perspective	Tony to check on current GW work and insert appropriate text into the DD report	Water tech	Addressed in reporting
Page 20 – Last Dot Point –	From memory, we discussed quarterly cleanout of the sediment forebay with Stantec.		Check clean out rate	Water tech	This will be updated in the detailed designed phase
Page 21 – Section 2.7.1 –	We agree with the comment regarding including a section within the report relating to approvals. We note that further liaison should be undertaken with DES to confirm this matter before the report is amended. This also applies to subsequent DAF and Approvals and Compliance cost actions.	Further to Water Tech meeting with DES, it is recommended addition of a section in the DD report on the potential permitting/licensing outcomes. If there are no minutes taken from the meeting with DES then it is best for the report to include the suggestions provided by DES on the day and be referenced as pers comm. monitoring of health of mangroves vs monitoring of water quality.	Water Tech to include permitting/approvals section in the DD report	Water tech	GHD review added to the section (Section 7) - also ties in with ties in with line 34 in this spreadsheet
	Email from Shane O'Brien - Stantec Australia				
Section 2.4.4 –	check disinfection requirements for the effluent for log removals – this is part of the detailed design of the STP	noted	amend to acknowledge that this part of detailed design	GHD	Line added in Section 4.3.3 "Although validation of virus removal is typically not required for effluent discharge, a more detailed consideration of effluent disinfection may be required in the future design process"
Section 2.6.1 –	loading rates for the freshwater wetland. GHD should outline the effluent quality going into the example wetlands. They are assuming that we are required to remove certain levels of nutrients – but we are not committed to any particular level. Tony will need to reconsider the use of the freshwater wetland and loading rate and advise so that I can change the replacement costs for the OPEX. Associated with this is GHD comment on weeding and replanting costs that I need to review.	same as line 23	review fw wetland	water tech	Freshwater wetland design will be given further consoderation in future assessments for detailed design
Section 2.6.3 –	use of 100,000 m3 of treated ASS at the STP site – might need to come up with what we are using this for as we have a lot of cut and therefore likely to have enough fill for the works. Any other ideas of where to use this volume? Sounds like a detailed design question?		Stantec and Water Tech to review and add wording on reuse of material on shoreline dvp site	Stantec Water Tech	Section 4.10 has been amended
	Redland Water concerns raised at 30 October 2019 meeting				
	Assumptions re bypass – Stantec/Water Tech to confirm	as above - add commentary on bypass within the report	Water tech to add	Water tech	See line 5 of spreadsheet
	Receiving waters – if there is a licence breach, where is this recorded from	Further to Water Tech meeting with DES, it is recommended addition of a section in the DD report on the potential permitting/licensing outcomes. If there are no minutes taken from the meeting with DES then it is best for the report to include the suggestions provided by DES on the day and be referenced as pers comm. monitoring of health of mangroves vs monitoring of water quality.	Water Tech to include permitting/approvals section in the DD report	Water tech	Section added .
	Summary needed of further work required and cost comparison between outfall and mangroves (opex/capex)		Water tech cost comparison	Stantec Water tech	Ammended

Relevant section/page	Comments	GHD Response	Action	Responsibility	Status-Watertech update
	Acid Sulphate soils – liming the ASS, what does this do to mangrove growth		Water tech to include statement on this in the DD reprot GHD to comment in review report	Water tech GHD	Section 4.10 has been amended
	Smell of mangroves/falling fruit – what impact will these have?	at the meeting Lendlease and Water Tech agreed that this needs to be looked into further	DD report to include a sectio on odour impacts from the mangrove system as suggested by GHD section 2.4.6 talk to lendlease.	Water tech	A section (see line 16 of spreadsheet) has been added
	per capita sewage flow to consider 210m3/person vs 190		Stantec and Water Tech to review and amend as required	Stantec Water tech	Needs to be clarified - We use 150 L/person/day which is equivalent to 55m#/person/vear not 190 m3/person.
	Phillip Mann request				
	amend name of the project to Southern Redland Bay Wastewater Treatment Plant	noted	amend accordingly	GHD	Amended to 'Southern Redland Bay WWTP and Mangrove Offset Program'
	references to sewerage treatment plant/STP can we please make to wastewater treatment plant/ WWTP for consistency with documents.	noted	amend accordingly	GHD	Amended throughout the document

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APPENDIX K
COASTAL PROCESSES



MEMORANDUM

To Joel Salmon/Phil Mann (Lendlease) and Keira Grundy/Nick Christofis (Saunders-Havill Group)

From Dr. Shiv Umapathi/Tony McAlister, Water Technology

Date 18 September 2020

Subject Southern Redland Bay WWTP (WT Ref 20020099) – Coastal Processes Assessment

1 SITE LOCATION

The proposed Southern Redland Bay Wastewater Treatment site ("The Site") is located to the south of 38 Longland Road, Redland Bay, on an outer bend of the Logan River, about 7.5 km upstream from the mouth of the river. The Site extends over four (4) lots within Redland City Council, bearing lot numbers 3RP223470, 2RP223470, 254S31102 and 1SL3427. The Site will consist of a Mangrove Offset Area (MOA) and Freshwater Lagoon (FWL), with an adjacent Wastewater Treatment Plant (WWTP) to the east of the Site (see Figure 2-1). Adjacent to the lots, on the western side is Logan City Council, at the southern end is the Logan River, rural property is on the eastern side and the northern side is adjacent to Beenleigh-Redland Bay Road.

2 BACKGROUND

2.1 General Introduction

The proposed Southern Redland Bay WWTP involves the designation of land at 38 Longland Road, Redland Bay for the construction of a new Membrane Bioreactor (MBR) WWTP, creation of a new mangrove forest fringed by salt couch areas (referred to as a Mangrove Offset Area) and ancillary infrastructure including the modification of an existing freshwater lagoon (referred to as the Freshwater Lagoon) to support the WWTP. The mangroves will offset nutrients from the wastewater treatment plant through nitrogen retention/de-nitrification and phosphorus capture and storage (with the added benefit of offsetting carbon as a carbon sink) as an alternative to constructing a treated effluent outfall into Southern Moreton Bay.

As identified in the Queensland Government's Development Assessment Mapping System (DAMS), an assessment of coastal processes associated with the Site is required in the Infrastructure Designation (ID) process due to the Site being located within the following areas:

- Coastal Management District (See Figure 2-2);
- Partly within the Medium and High Storm Tide Inundation Area (See Figure 2-3); and
- Partly within the Erosion Prone Area (See Figure 2-4).

A Development Assessment (DA) for this site will be referred to the State Assessment and Referral Agency (SARA). Therefore, a coastal processes assessment associated with the Site must be addressed in the Infrastructure Designation (ID) process.

This document presents an assessment of potential coastal hazards and provides informed responses to State Code 8 of Queensland's State Development Assessment Provision (SDAP), as well as addressing issues associated with Council's Flood Prone, Storm Tide and Drainage Constrained Land Overlay.

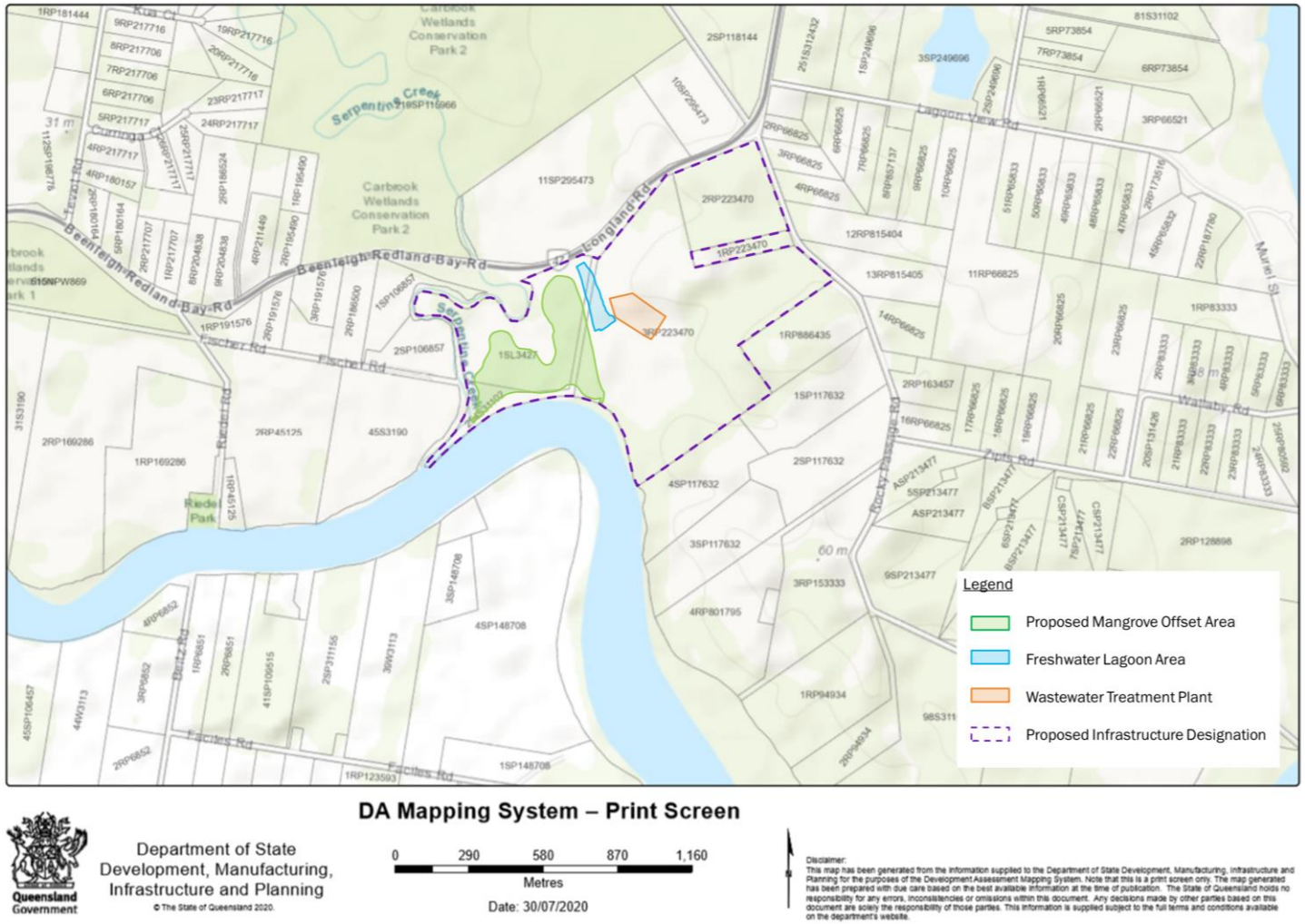


Figure 2-1 Proposed Southern Redland Bay WWTP Project Site and surrounding areas (Source: Queensland Government Development Assessment Mapping System)

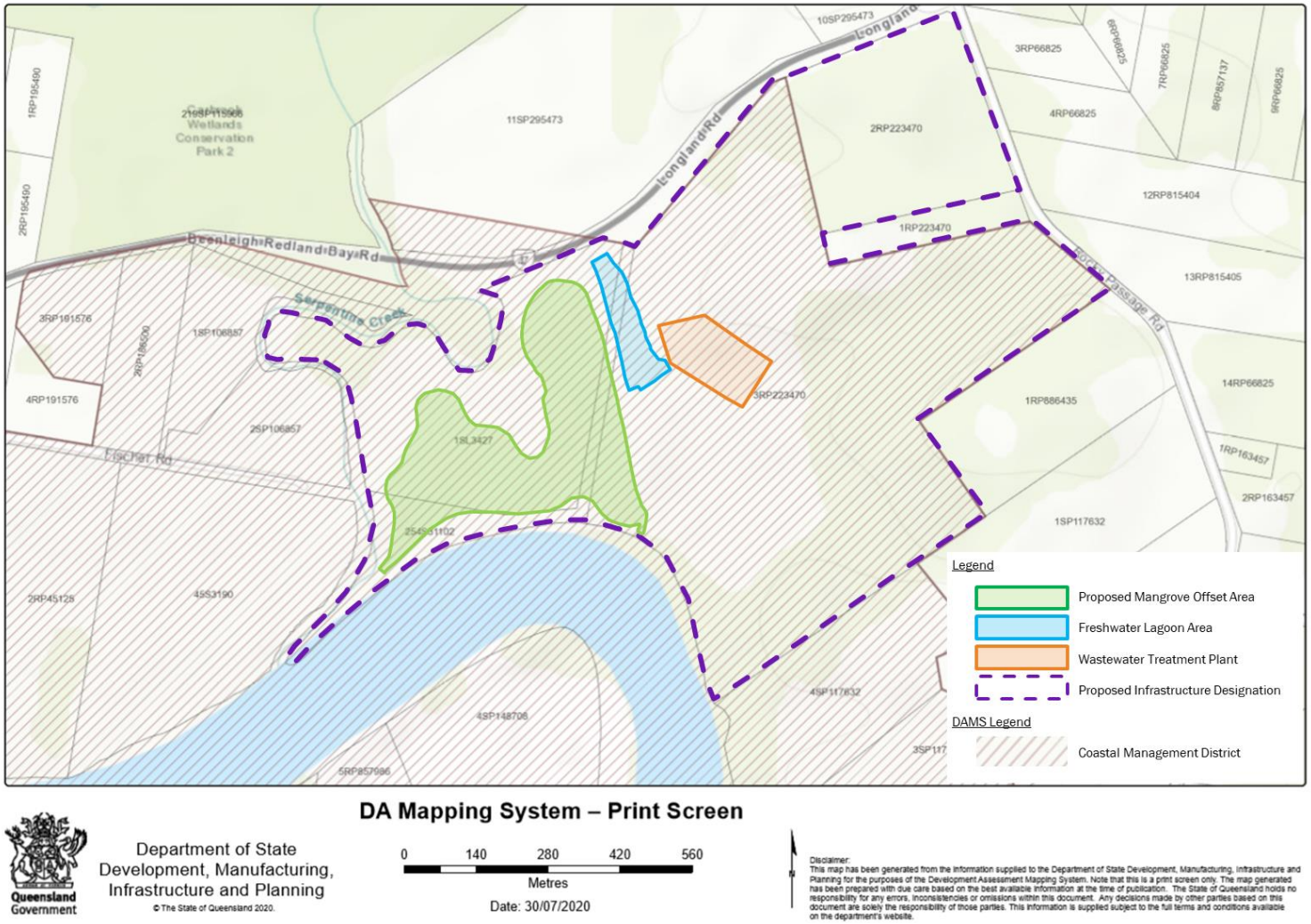


Figure 2-2 Location of the Site within the Coastal Management District (Source: Queensland Government Development Assessment Mapping System)

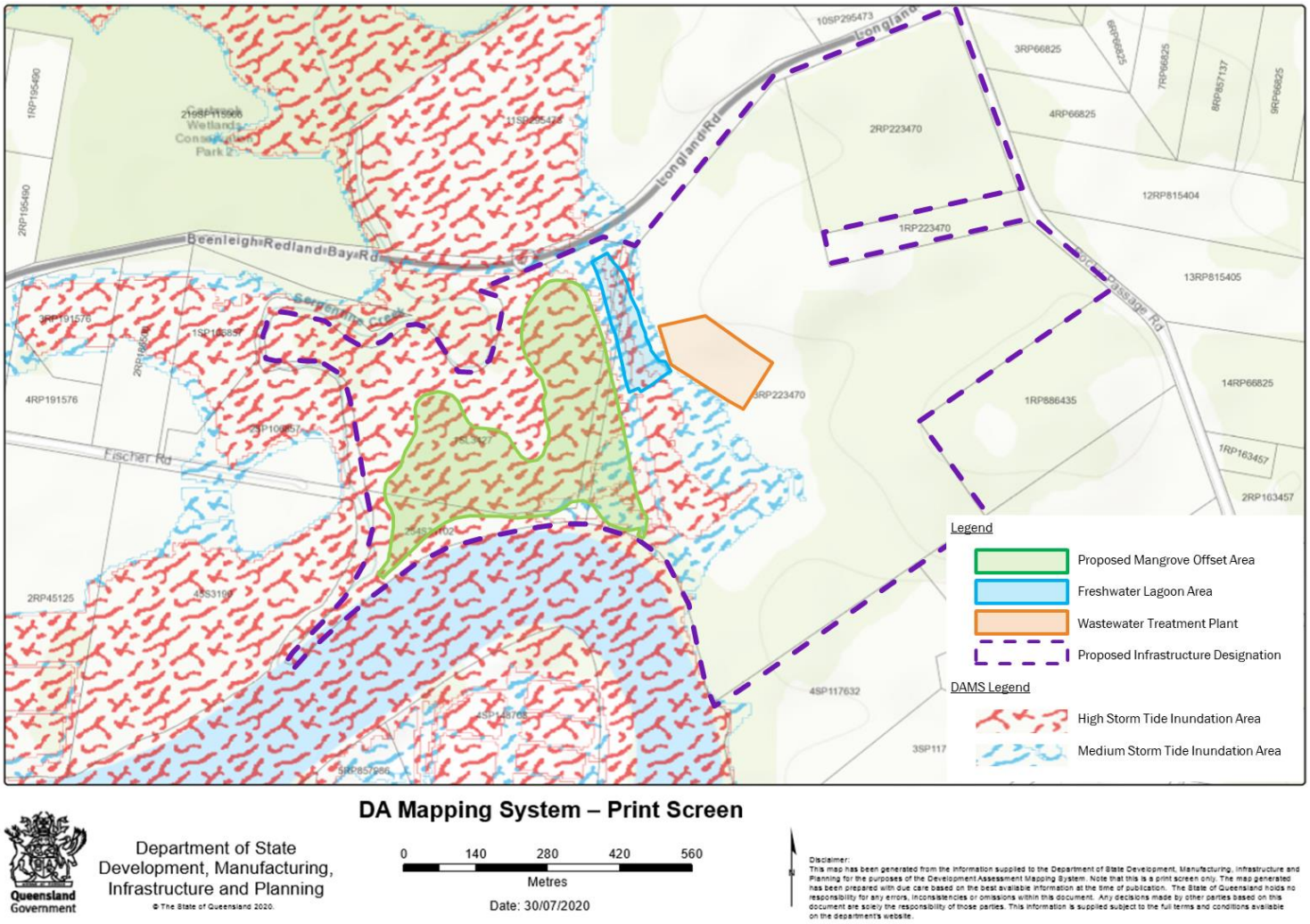


Figure 2-3 Storm Tide Inundation Areas (Source: Queensland Government Development Assessment Mapping System)

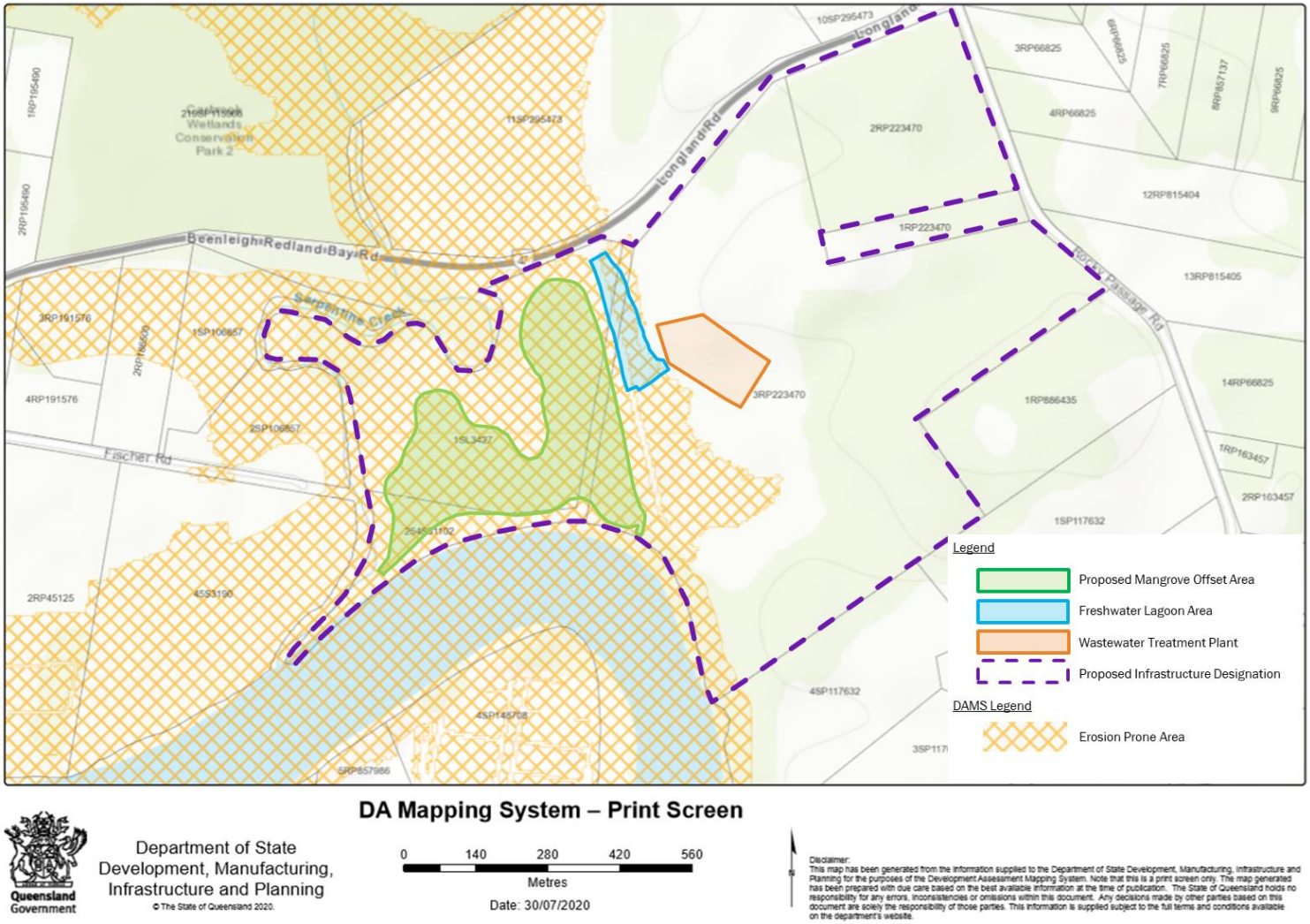


Figure 2-4 Erosion Prone Areas (Source: Queensland Government Development Assessment Mapping System)

2.2 Relevant Documents

Assessments and draft plans that serve as background to this assessment are as follows:

- Assessments:
  - Ecological Assessment Report (Flora and Fauna) - MNES and MSES;
  - Site-based Management Plans – Mangrove Offset Area (Draft);
  - Water Quality and Management Report (Draft);
  - Shoreline WWTP and Approvals – Draft Operational Environmental Management Plan;
  - Southern Redland Bay WWTP – Recycled Water Strategy (Draft Report);
  - Southern Redland Bay WWTP Concept Design Report; and
  - Southern Redland Bay Wastewater Treatment Plant Options Assessment Report;
- Plans:
  - Proposal Plans for the Southern Redland Bay Wastewater Treatment Project;
  - Concept Mangrove Rehabilitation Plan;
  - Concept WWTP/Storage Lagoon Rehabilitation Plan;
  - Engineering Plans;
  - Existing Site Plans;
  - Extent of Works in Serpentine Creek;
  - Detailed Property Map of Assessable Vegetation (PMAV); and
  - Vegetation Clearing and Fauna Management Plan;

3 COASTAL PROCESSES

3.1 Ocean Water Levels

The site is located adjacent to an outer bend of the Logan River, about 7.5 km upstream from the mouth of the river. Currently the site is intermittently inundated by tides of the order of Mean High Water Springs via Serpentine Creek and other small waterways. Once developed, incoming tides will inundate the Mangrove Offset Area via a unidirectional inlet to the east of the site and then drain out through a unidirectional outlet to Serpentine Creek to the west of the site. The Site will experience regular inundation during all tidal cycles.

This document addresses the influences of storm tide and climate change to indicate potential impacts on the proposed site. When considering potential coastal hazards, the following ocean levels can occur from time to time:

- Astronomical Tide - this is the “normal” rising and falling of the ocean in response to the gravitational influences of the moon, sun and other astronomical bodies. These effects are predictable and consequently astronomical tide levels can be forecast with confidence.
- Storm Tide - this is the combined action of the astronomical tide and any storm surge that also happens to be prevailing at the time. A ‘surge’ can be defined as a rise above normal water level as a consequence of surface wind stress and atmospheric pressure fluctuations induced by synoptic events, such as severe storms or cyclones.

- Climate change - this is the combined effect of environmental changes as a consequence of future climate scenarios. One of these possible effects is an increase in ocean water levels.

The assessment in this document provide the context and basis for the responses to State Code 8 that are provided in Appendix A.

3.2 Astronomical Tide

Tidal planes at the Logan River mouth (Rocky Point) are presented in Table 3-1. The Logan River is strongly tidally influenced, and it is therefore proposed that this be used as a driver to inundate the MOA.

Table 3-1 Tidal Planes at Logan River Mouth (Source: Department of transport and Main Roads)

Tidal Plane	To AHD (m)	To LAT (m)
Highest Astronomical Tide (HAT)	1.53	2.63
Mean High Water Springs	0.99	2.09
Mean High Water Neaps	0.62	1.72
Australian Height Datum (AHD)	0.00	1.10
Mean Sea Level	0.11	1.21
Mean Low Water Neaps	-0.36	0.74
Mean Low Water Springs	-0.73	0.37

3.3 Storm Tide

The combination of astronomical tide and storm surge is known as a storm tide. If the maximum surge should happen to coincide with a high spring tide, higher water levels are expected. Figure 3-1 illustrates the primary water level components of a storm tide event.

Different storm tide scenarios have been modelled by Cardno (2009) for the Redland City Council Storm Tide Hazard Study. Table 3-2 shows the annual exceedance probability for 5%, 2% and 1% events, which indicate a return period of 20 years, 50 years, and 100 years, respectively. The levels presented are without sea level rise or wave run-up/set-up.

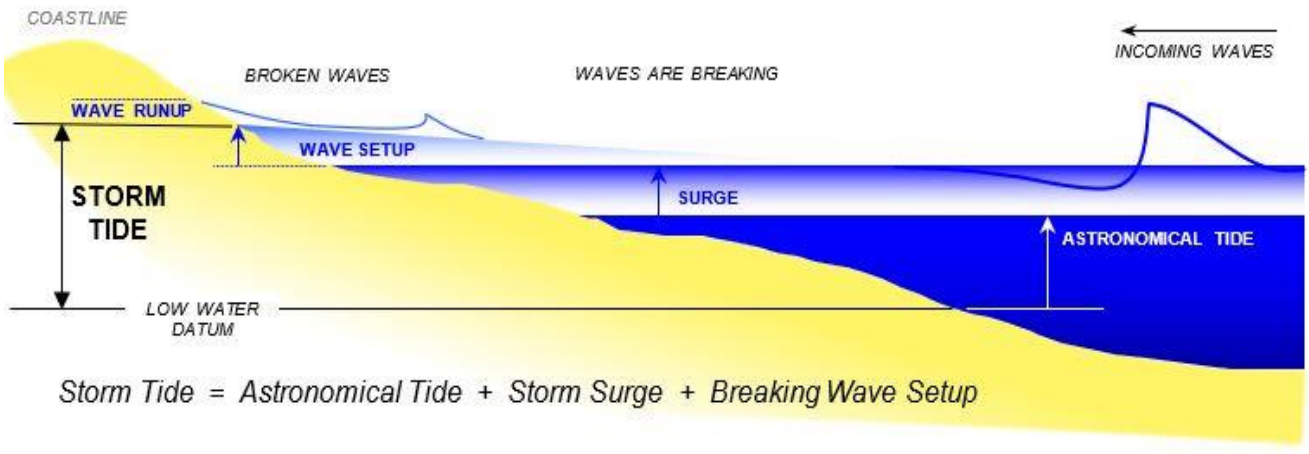


Figure 3-1 Components of a storm tide event

Table 3-2 Storm Tide Levels for Different Return Periods (Cardno, 2009)

Annual Exceedance Probability (AEP)	Storm Tide Level – non-cyclonic (Appendix H) (metres above AHD)	Storm Tide Level – cyclonic (Appendix J) (metres above AHD)
5%	2.22	2.04
2%	2.33	2.21
1%	2.40	2.34

3.4 Future Climate Change

When considering the effects of future climate scenarios on coastal areas, the State Government (DEHP, 2013) prescribes that for planning purposes and based on current science it is appropriate to assume the following impacts in year 2100:

- Sea level rise of 0.8m;
- Southward latitude shift in the tropical cyclone climate of approximately 1.3 degrees; and
- Increase in cyclone maximum potential intensity of 10%.

The Redland City Council Storm Tide Hazard Study investigated the effect of future climate scenarios, including a shift in likely cyclone tracks and predicted increases in the intensity of tropical cyclones in the region, but did not report likely future storm tides under a 0.8 metre sea level rise scenario.

The Queensland Department of Environment and Heritage Protection (now Department of Environment and Science) publication “Coastal hazard technical guide – Determining coastal hazard areas” (DEHP, 2013) notes that when updating earlier storm tide statistics, an additional 0.8 metres (to account for sea level rise to the year 2100) can be added to reported storm tide levels. Therefore, 0.8 metres is added to the storm tide levels reported by Cardno (2009) for scenarios that consider other greenhouse related effects on cyclone tracks and their intensities (Appendix K). The resulting storm tides are presented in Table 3-3.

Table 3-3 Estimated Storm Tide Levels for the Site – Climate Scenario in Year 2100

Annual Exceedance Probability (AEP)	Storm Tide Level (metres above AHD) EXCLUDING sea level rise	Storm Tide Level (metres above AHD) INCLUDING sea level rise
5%	2.23	3.03
2%	2.46	3.26
1%	2.63	3.43

4 ASSESSMENT OF POTENTIAL INFLUENCES AND HAZARDS

An assessment of potential coastal hazards is required to provide informed responses to State Code 8 of Queensland’s State Development Assessment Provision, as well as to address issues associated with Council’s Flood Prone, Storm Tide and Drainage Constrained Land Overlay. Such hazards are due to:

- Inundation during normal astronomical tidal cycle;
- Potential inundation by storm tide (including the effects of sea level rise under future climate scenarios); and
- Potential adverse implications of shoreline erosion.

The implications of these hazards at the site location are discussed below and detailed responses to State Code 8 performance outcomes are presented in Appendix A.

4.1 Astronomical Tide Inundation

4.1.1 Mangrove Offset Area and Freshwater Lagoon

Tides will enter the site post construction via a unidirectional inlet connected to a small waterway to the east of the site and pass through a designated sediment basin before inundating the remainder of the MOA. The level of the mangrove area varies and will be inundated to varying degrees during all tidal cycles. The saltmarsh area surrounding the mangroves is located above MHWS in the mangroves. At the downstream end of the project area, water discharges through another unidirectional outlet to Serpentine Creek from which it flows back into the Logan river.

Sea level rise is expected to be 0.8m by 2100. This means that the project site will gradually flood more often with rising sea levels. As sea level rise will occur gradually, it is expected that the mangroves will accommodate the change and move landward. This means that in a future sea level rise scenario, the mangroves might be less vigorous in the lower levels that are being inundated more often and establish in areas of future higher water levels. Fine sediment accretion within the MOA is expected over time, resulting in a slow growth of the ground levels which may assist the MOA retain additional mangroves.

4.1.2 MBR Wastewater Treatment Plant

The MBR WWTP will be located at a minimum level of 10m AHD and approximately 320 m from the Logan shoreline. The location of the WWTP is not influenced by tides. The WWTP is located well above 1.53m AHD, which is the highest astronomical tide (HAT) level.

Sea level rise is expected to be 0.8m by 2100. Assuming that the tidal range will remain the same with sea level rise, the future level of MHWS and HAT would be 1.79m AHD and 2.33m AHD, respectively. This means that the WWTP infrastructure site will still not be inundated in the future once the full sea level rise of 0.8m has occurred.

4.2 Storm Tide Inundation

4.2.1 Mangrove Offset Area and Freshwater Lagoon

State Code 8 states that for a development site, the Defined Storm Tide Event (DSTE) should be equivalent to a 1% AEP storm tide event, incorporating sea level rise and the increased cyclone intensity expected under a changing climate. In other words, it represents the 1% AEP storm tide event that is expected in the year 2100. This value is to ensure proposed building site levels are above the defined storm tide event. The purpose of this development site is not to accommodate any building or recreational activity but to provide a mangrove habitat and therefore, nutrient offsets.

Investigations of the storm tide inundation hazard overlay indicate that the whole site is already within the high to medium hazard area, see Figure 2-3. The DSTE for the Site is 2.63mAHD (Table 3-3, excluding sea level rise), so about 1.64m above the usual level of MHWS, and 1.1m above the level of HAT. With sea level rise of 0.8m by 2100, water levels can be expected to be even higher.

It is expected that increased inundation of the Site during a storm tide event can be accommodated. Most importantly, as mangroves are adaptable to temporarily increased inundation (storm tide event) and long-term changes in water levels such as sea level rise due to climate change (Saintilan, N. et al, 2013), the MOA will in fact help mitigate the effects of potential flooding of the shoreline. Vegetation can accommodate the increased levels over a short period of time and infrastructure such as the Site access footpath and sediment

basin can be flooded without major damage. However, some repair work may be required after an inundation event.

Storm tide inundation may render the FSL brackish. However, the effects of storm tide events are only expected to be temporary.

Inflowing waters may have higher sediment concentrations during a storm tide event. Therefore, the whole site may experience some short-term sediment deposition. However, mangroves thrive in environments that experience modest amounts of sediment accumulation and therefore infrequent storm tide inundation is not expected to be detrimental to the MOA.

Due to the location of the Site being approximately 7.5km upstream from Moreton Bay, waves are not expected to impact on the Site during a storm surge event.

4.2.2 MBR Wastewater Treatment Plant

The location of the proposed MBR WWTP is not triggered by the medium or high inundation hazard area mapping and is therefore exempt from assessment under Code 8 performance outcomes. The location of the proposed MBR WWTP will not be affected by storm tide inundation.

Due to the location of the Site being approximately 7.5km upstream from Moreton Bay, waves are not expected to impact on the Site during a storm surge event.

4.3 Flooding

4.3.1 Mangrove Offset Area and Freshwater Lagoon

In addition to storm tides, the Site can be impacted by fluvial floods. The difference is that the water will enter the Site via overland flow from Serpentine Creek and not via the inlet/sediment basin. Intermittent flooding may lead to short term increased sediment deposition on the Site, depending on the sediment loads during a flood event.

4.3.2 Wastewater Treatment Plant

Due to its elevation, the location of the proposed WWTP will not be affected by fluvial flooding.

4.4 Storm Wave Overtopping of Coastal Foreshore

The wave climate at the Site is benign, even during severe storm events in the offshore waters. North Stradbroke Island and the islands in between protect the river mouth from ocean storm events. Wave penetration is not likely, and the only form of wave action would be from boats travelling along the Logan River. Consequently, there will be negligible overtopping occurring on the natural foreshore frontage of the Site due to wave action.

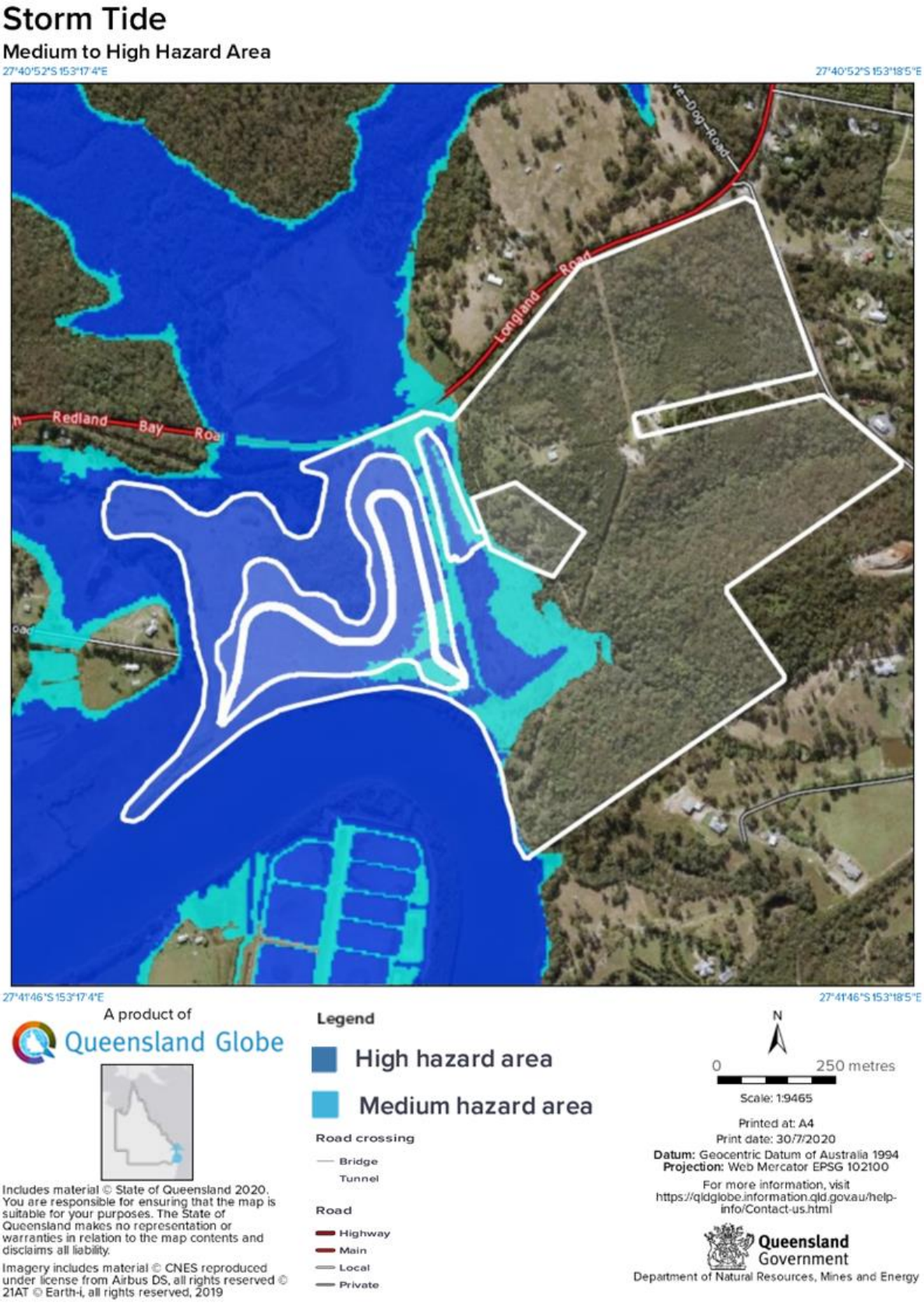


Figure 4-1 Medium to High Inundation Hazard Area (Source: Queensland Globe)

4.5 Erosion Prone Area

The Coastal Hazard Technical Guide (DEHP, 2013) sets out the rules for determining Erosion Prone Areas (EPAs) for all of Queensland. The extent of the EPA in tidal waters is generally defined by the State for the year 2100 by the maximum of:

- Highest Astronomical Tide (HAT) plus 40m buffer; or
- Highest Astronomical Tide (HAT) plus 0.8m sea level rise.

The Site is partially located within the EPA (See Figure 4-2 and Figure 4-3). Generally, development in the EPA is recommended to be avoided - unless it is a coastal dependent development.

4.5.1 Mangrove Offset Area and Freshwater Lagoon

The mangrove offset area and freshwater lagoon area within the Site are located within the EPA (see Figure 4-2 and Figure 4-3). The HAT + 0.8 m sea level rise component is the governing component in these areas. Due to the MOA and salt couch in these areas being tidally dependant (mangroves and salt couch habitats in the region are tidally influenced), the Site's location in an EPA is a matter of least concern (See Section 4.6.3 for further details).

Erosion around the periphery of the site and in proximity to the proposed locations of the hard infrastructure could occur. Therefore, it is recommended that this document is read in conjunction with the Engineering Plans (KN Group) for hard infrastructure within the Site such as the tidal inlet and outlet, sediment basin and access path. From a coastal processes perspective, it is recommended that the following are considered in the design of hard infrastructure within the Site:

- Measures to limit erosion around the tidal inlet and outlet structures; and
- Measures to mitigate erosion around access paths.

4.5.2 MBR Wastewater Treatment Plant

The location of the proposed MBR WWTP infrastructure is not within the extent of the mapped EPA and therefore is a matter of no concern. The MBR WWTP, which is classified as 'essential community infrastructure', is located outside of the EPA.

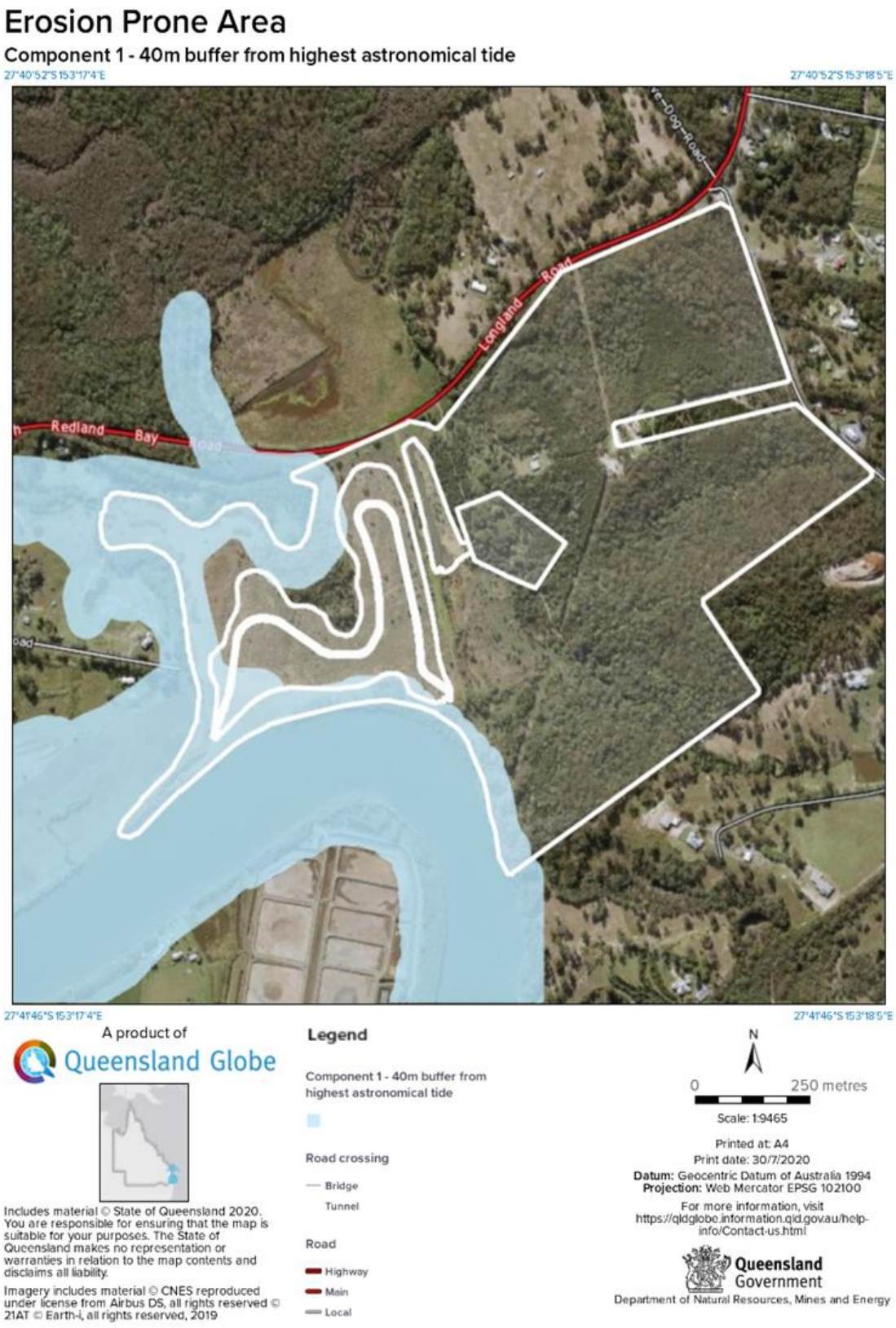


Figure 4-2 State Erosion Prone Area (Source: Queensland Globe)



Figure 4-3 State Erosion Prone Area – Sea Level Rise (Source: Queensland Globe)

4.6 Other Considerations

4.6.1 Vegetation

An important factor when assessing the erosion potential of creek and riverbanks is the state of natural vegetation. Vegetation is an important indicator of the resistance to erosion. Heavily vegetated banks tend to experience limited erosion and can withstand higher flow velocities than non-vegetated banks.

There is currently an increased focus on research into natural vegetation at foreshore areas. Preliminary findings suggest that natural vegetation and restored wetlands can protect shorelines effectively. Therefore, maintaining and protecting existing vegetation buffers is a highly efficient foreshore protection approach.

Highly vegetated riverbanks are generally able to withstand velocities of up to 2.5 to 3.0 m/s (Figure 4-4). Based on modelling conducted for this project, tidal velocities at the inlet and in the outer bend are expected to peak at 0.6 and 0.45 m/s respectively during normal conditions (no flooding or storm tide event). The velocities are peak values only, which means that the banks are subject to those velocities only for a short period of time. Small waves from boat wash will increase pressures on the riverbank, but a well vegetated bank will be able to withstand normal non-commercial boat wash.

Velocities during larger flooding or storm tide events are not known at this stage and there may be potential for damage to bank vegetation and some resulting erosion in the area after a major flood event. Maintenance of the riverbank vegetation is included in the site plans to avoid the need for hard engineering solutions. See Vegetation Management Plans and Ecological Assessment Report for further details.

Bank Condition	Typical bank scour velocity * (m/s)
Non vegetated banks:	
Highly erodible sand-loam soils	0.5
Moderately erodible clay-loam soils	0.6
Lean clayey soils	0.6 to 1.2
Heavy clayey soils	0.7 to 1.5
Poorly vegetated banks:	
Banks with sparse groundcover	1.0 to 1.5 (depending on soil erodibility)
Well vegetated, erosion-resistant soils:	
Grassed banks	2.0
Banks with thick shrub and tree cover	2.5
Banks with a good coverage of fibrous-rooted herb layer plants such as "Lomandra"	3.0

Figure 4-4 Source: Typical Bank Scour Velocities (Extracted from 'Stormwater Outlets in Parks and Waterways, Brisbane City Council Version 2/2003)

4.6.2 Historical Changes

As the Site is located at the outside bend of the Logan River, it is more prone to erosion than other areas of a river such as straight sections or within inside bends. Rivers tend to migrate in the direction of the outer river bend until a cut-off occurs. An investigation of historical imagery indicates that the river bank has not moved appreciably in some 62 years, as illustrated in Figure 4-4. As such, it is apparent that the banks of the river are well established and not subject to long term erosion.



Figure 4-5 Left Aerial Image from 1955 and Right Aerial Image from 2017 (Source : Qimagery, Queensland Government)

Based on the above assessment, and observations made on several site inspections, it is apparent that the riverbank is stable and shows no signs of long-term erosion. To reinforce this, it will be important to continue to maintain a well vegetated riverbank and keep any development works (e.g. maintenance access paths) sufficiently landwards of the banks such that there are no impacts.

Local erosion around the inlet and outlet structures has been considered and addressed separately (see Engineering Plan Drafts, Concept WWTP/Storage Lagoon Rehabilitation Plan and Concept Mangrove Rehabilitation Plan). Some rock protection around those structures may be required within the unnamed waterway to the east of the site and Serpentine Creek to the west, neither of which will affect stability of the banks of the Logan River.

4.6.3 Tidal Prism and Shoreline Erosion

Tidal prism is defined as the volume of water that flows through a channel cross-section during the flood tide (low water slack to high water slack). The tidal prism is useful for identifying potential erosion issues associated

with modifications to the estuary and contextualising freshwater inflows. Calculations of tidal flows are useful in determining the residence time of water (and pollutants) in an estuary and potential erosion issues associated with changes in the flows.

The establishment of the MOA will change the tidal prism of the river. The tidal prism for a section of the river just downstream of the site was derived using a calibrated and validated TUFLOW-FV numerical model for both spring and neap tides for two scenarios, one when treated effluent is permitted to discharge into the Southern Redland Bay Mangroves and one without treated effluent discharge and also without the MOA (that is, the 'base' case). At the full operational capacity of the WWTP and upon complete establishment of the mangrove/saltmarsh habitats, the change in tidal prism of the Logan estuary was estimated to be between 0.6% (during neap tides) and 1.5% (during spring tides). These changes are small and will have no impact on bed and bank stability or coastal processes within adjacent sections of the Logan River. Therefore, erosion/migration of the riverbank is anticipated to be best managed by maintaining currently stable and well vegetated riverbanks. It is anticipated that long-term recession of foreshores due to longshore sediment transport differentials, migration and geomorphologic changes to estuaries and tidal inlets, and impacts of other works and structures along the shoreline will not have a detrimental impact on the Logan River, the proposed MOA, Freshwater Lagoon or the WWTP.

Although Serpentine Creek is outside the site boundaries, it is important that vegetation along the banks of the creek is maintained and preferably revegetated to mitigate changes in flows in this waterways and potential erosion. Spraying of mangroves in Serpentine Creek was noted during site investigations and it is recommended that this be avoided in the future.

4.7 Ancillary Infrastructure

4.7.1 Mangrove Offset Area and Freshwater Lagoon

A maintenance path is proposed around the Mangrove Offset Area and along the riverbank from the WWTP and inlet structure to the downstream outlet structure. The purpose of this path is general maintenance and works access to the Site. The path will not be used for recreational purposes.

4.7.2 MBR Wastewater Treatment Plant

All ancillary infrastructure surrounding the WWTP is not at risk of inundation. See separate WWTP Layout Plans for detailed location and levels.

5 CONCLUSIONS AND RECOMMENDATIONS

- The site currently inundates under larger tides. After development of the MOA, this inundation will be more frequent (every tide) and will be carefully controlled by dedicated inlet and outlet structures.
- Erosion/migration of the riverbank is best protected by maintaining the currently stable and well vegetated riverbanks along the Logan Estuary and Serpentine Creek.
- Early involvement of State agencies in the approval process will benefit project outcomes by ensuring that all parts of the proposed development are acceptable. Although Serpentine Creek is outside the site boundaries, it is important that the vegetation along the banks of Serpentine Creek is maintained and preferably revegetated to mitigate any potential for localised erosion.
- The development will cause no detrimental impacts on adjacent properties or other areas within the coastal zone.
- The development will not adversely impact coastal resources and public amenity of foreshore areas, either at the development site or in adjacent areas.

- Disposal of sediment from the sediment basin will need to be addressed and a management plan developed.

6 REFERENCES

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WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX A
STATE CODE 8: COASTAL DEVELOPMENT AND TIDAL WORKS – RESPONSE DOCUMENT



STATE CODE 8: COASTAL DEVELOPMENT AND TIDAL WORKS – RESPONSE DOCUMENT

6.2 Purpose statement

The purpose of this code is to ensure that development is designed and located to:

1. protect life, buildings and infrastructure from the impacts of **coastal erosion**
2. maintain **coastal processes**
3. conserve **coastal resources**
4. maintain appropriate public use of, and access to and along**, state coastal land**
5. account for the projected impacts of climate change; and
6. avoid impacts on **matters of state environmental significance** and, where avoidance is not reasonably possible, minimise and mitigate impacts, and provide an **offset** for **significant residual impacts** where appropriate.

In addition to the above, the purpose of this code is to ensure that development involving operational works which is not assessed by local government is designed and located to protect life and property from the impacts of **storm tide inundation**.

Note: Guidance on achieving compliance with the performance outcomes and acceptable outcomes in the code is provided in the Guideline – SDAP State code 8: Coastal development and tidal works, Department of Environment and Heritage Protection, 2016. Guidance for determining if development will have a significant residual impact on a matter of state environmental significance is provided in the Significant Residual Impact Guideline, Department of State Development, Infrastructure and Planning, 2014.

6.3 Performance outcomes and acceptable outcomes

All development should demonstrate compliance with the relevant provisions of table 8.2.1. Development involving operational work should also demonstrate compliance with the relevant provisions of table 8.2.2. Development involving operational work which is not assessed by local government should demonstrate compliance with the relevant provisions of table 8.2.1, table 8.2.2 and table 8.2.3.

Table 8.2-1 All development

Performance outcomes	Acceptable outcomes	Response
Development in the erosion prone area		
PO1 Development does not occur in the **erosion prone area** unless the development: 1. is one of the following types of development: a. **coastal-dependent development**; or b. **temporary, readily relocatable or able to be abandoned**; or c. **essential community infrastructure**; or d. **redevelopment** of an existing permanent building or structure that cannot be relocated or abandoned; and cannot feasibly be located elsewhere.	No acceptable outcome is prescribed.	**Complies** The Mangrove Offset Area and the Freshwater Lagoon within the Site are located within the Erosion Prone Area, however, they are tidal dependant habitats and it is anticipated that when the mangroves have established, they will in fact assist in mitigating the effects of erosion and are also expected to withstand increasing pressures from climate change impacts. All infrastructure for the WWTP is proposed to be located well above and beyond indicated storm tide levels and outside the erosion prone areas. The MBR WWTP, which is classified as 'essential community infrastructure', is located outside of the EPA.

Performance outcomes	Acceptable outcomes	Response
PO2 Development other than **coastal protection work**: 1. avoids impacting on **coastal processes**; and 2. ensures that the protective function of landforms and vegetation is maintained. **Note:** In considering reconfiguring a lot applications, the state may require land in the **erosion prone area** to be surrendered to the State for coastal management purposes under the *Coastal Protection and Management Act 1995*. Where the planning chief executive receives a copy of a land surrender requirement or proposed land surrender notice under the *Coastal Protection and Management Act 1995*, this must be considered in assessing the application.	No acceptable outcome is prescribed.	**Complies** The development is expected to have a minor, albeit positive impact on coastal processes. The Mangrove Offset Area and the Freshwater Lagoon within the Site are located within the Erosion Prone Area, however, they are tidally dependant and it is anticipated that when the mangroves have established, they will in fact assist in mitigating the effects of erosion and are also expected to withstand the increasing pressures from climate change impacts. All infrastructure for the WWTP is proposed to be located well above and beyond the indicated storm tide levels and outside the erosion prone areas. The development will affect existing landforms on site (due to excavations as part of the development) to enable the establishment of mangroves. A separate vegetation plan has been developed as part of the development.

Performance outcomes	Acceptable outcomes	Response
PO3 Development is located, designed and constructed to minimise the impacts from **coastal erosion** by: 1. locating the development as far landward as practicable; or where it is demonstrated that 1 is not feasible, mitigate or otherwise accommodate the risks posed by **coastal erosion**.	No acceptable outcome is prescribed.	**Complies** The Mangrove Offset Area and the Freshwater Storage Lagoon within the Site are located within the Erosion Prone Area, however, as mangroves are tidally dependant, it is anticipated that when the mangroves have established, they will in fact assist in mitigating the effects of erosion and are also expected to withstand the increasing pressures from climate change impacts. Due to the nature of the proposed Mangrove Offset Area and the existing location of the Freshwater Lagoon, placing the development outside the erosion prone area within the site boundaries defeats the purpose of this type of development. All infrastructure for the MBR WWTP is proposed to be located well above and beyond the indicated storm tide levels and outside the erosion prone areas.
PO4 Development does not significantly increase the risk or impacts to people and property from **coastal erosion**.	No acceptable outcome is prescribed.	**Complies** The development does not increase the erosion risk or impacts to people or property. No habitable structures are located within the EPA, only the coastal dependent vegetation. No public access to the site.

Performance outcomes	Acceptable outcomes	Response
PO5 Development other than **coastal protection work** avoids directly or indirectly increasing the severity of **coastal erosion** either on or off the site.	No acceptable outcome is prescribed.	**Complies** The development does not increase the severity of erosion on or off the Site as no changes to the nature of the riverbank are proposed and the development does not result in significant changes to flow velocities and therefore bank erosion. All infrastructure for the MBR WWTP is proposed to be located well above and beyond the indicated storm tide levels and outside the erosion prone areas.
PO6 In areas where a **coastal building line** is present, building work is located landward of the **coastal building line** unless **coastal protection work** has been constructed to protect the development.	No acceptable outcome is prescribed.	**Not applicable** A coastal building line is not present on the site.
Artificial waterways		
PO7 Development of **artificial waterways**, canals and **dry- land marinas** minimises impacts on **coastal resources** by: 1. maintaining the **tidal prism volume** of the natural waterway to which it is connected demonstrating a whole-of-life strategy for the disposal of **dredged material**.	No acceptable outcome is prescribed.	**Compliant** At the full operational capacity of the proposed Southern Redland Bay WWTP and upon the establishment of the mangrove/saltmarsh habitats, the change in the tidal prism in the Logan estuary was estimated to be between 0.6% (during neap tides) and 1.5% (during spring tides). These changes in tidal prism are particularly small and will have no potential impact on bed and bank stability or coastal processes within adjacent sections of the Logan River.
Coastal protection work		

Performance outcomes	Acceptable outcomes	Response
PO8 Works for **beach nourishment** minimise adverse impacts on **coastal processes** and avoid any increase in the severity of erosion on adjacent land by: 1. sourcing sand from an area that does not adversely impact on the active beach system ensuring imported sand is compatible with natural beach sediments and **coastal processes** of the receiving beach.	No acceptable outcome is prescribed.	**Not applicable** Development is not beach nourishment.
PO9 Erosion control structures are only constructed where there is an imminent threat to buildings or infrastructure of value, and there is no feasible option for either: 1. **beach nourishment**; or 2. relocation or abandonment of structures. **Note:** The monetary value of buildings or infrastructure should be more than the cost of associated erosion control structures.	No acceptable outcome is prescribed.	**Not applicable** Development does not include erosion control structures.
PO10 Erosion control structures minimise interference with **coastal processes**, or any increase to the severity of erosion on adjacent land by: 1. locating the **erosion control structure** as far landward as practicable and directly adjacent to the structure it is intended to protect 2. where required and feasible, importing sand to the site to mitigate any increase in the severity of erosion the design of the structure.	No acceptable outcome is prescribed.	**Not applicable** Development does not include erosion control structures.
Water quality		

Performance outcomes	Acceptable outcomes	Response
PO11 Development: 1. maintains or enhances **environmental values** of receiving waters 2. achieves the **water quality objectives** of Queensland waters 3. avoids the release of **prescribed water contaminants** to **tidal waters**. **Note:** See Environmental Protection (Water) Policy 2009 for the relevant water quality objectives.	No acceptable outcome is prescribed.	**Compliant** Separate detailed water quality analysis and reporting shows that the project will assist in achieving the desired EV's and water quality objectives and will appropriately manage the release of highly treated wastewater to the Logan River estuary.
Category C and R areas of vegetation		
PO12 Development: 1. avoids impacts on **category C areas** of vegetation and **category R areas** of vegetation; or minimises and mitigates impacts on **category C areas** of vegetation and **category R areas** of vegetation after demonstrating avoidance is not reasonably possible.	No acceptable outcome is prescribed.	**Complies** The site does not contain category R areas. Vegetation communities were ground-truthed as part of a PMAV assessment to inform the proposal and location of the WWTP. Subsequently, the development does not involve clearing of category C vegetation as ground-truthed via PMAV.
Public use of and access to state coastal land		
PO13 Development maintains or enhances public use of and access to and along state coastal land (except where this is contrary to the protection of coastal resources or public safety).	No acceptable outcome is prescribed.	**Not applicable** The development will not be open to the public due to safety aspects and no on-site dwellings are proposed.
PO14 Private marine development ensures that works: 1. are used for **marine access purposes** only 2. minimise the use of **state coastal land** do not interfere with access between **navigable waterways** and adjacent properties.	No acceptable outcome is prescribed.	**Not applicable** The development does not include private marine facilities.

Performance outcomes	Acceptable outcomes	Response
PO15 Development ensures **erosion control structures** are located within the premises they are intended to protect unless there is no feasible alternative.	No acceptable outcome is prescribed.	**Not applicable** The development does not include erosion control structures.
Matters of state environmental significance		
PO16 Development: 1. avoids impacts on **matters of state environmental significance**; or 2. minimises and mitigates impacts on **matters of state environmental significan**ce after demonstrating avoidance is not reasonably possible; and 3. provides an **offset** if, after demonstrating all reasonable avoidance, minimisation and mitigation measures are undertaken, the **development** results in an acceptable **significant residual impact** on a **matter of state environmental significance**. Statutory note: For Brisbane core port land, an offset may only be applied to development on land identified as E1 Conservation/Buffer, E2 Open Space or Buffer/Investigation in the Brisbane Port LUP precinct plan. For the Brisbane Port LUP, see www.portbris.com.au. **Note:** Guidance for determining if the development will have a significant residual impact on the matter of state environmental significance is provided in the Significant Residual Impact Guideline, Department of State Development, Infrastructure and Planning, 2014. Where the significant residual impact is considered an acceptable impact on the matter of state environmental significance and an offset is considered appropriate, the offset should be delivered in accordance with the *Environmental Offsets Act 2004*.	No acceptable outcome is prescribed.	Potential impacts to MSES for Biodiversity have been addressed under a separate cover (See Ecological Assessment Report by Saunders Havill Group).

Table 8.2-2 All operational work

Performance outcomes	Acceptable outcomes	
Private marine development		
PO17 Private marine development does not require the construction of **coastal protection work,** shoreline or riverbank hardening or **dredging** for **marine access purposes**.	No acceptable outcome is prescribed.	**Not applicable** Private marine development is not proposed.
Disposal of solid waste or dredged material from artificial waterways		
PO18 Solid waste from land and **dredged material** from **artificial waterways** is not disposed of in **tidal water** unless it is for **beneficial reuse**.	No acceptable outcome is prescribed.	**Not applicable** No dredged material from artificial waterways is expected. Material will be periodically removed from the sediment basin and will not be disposed of in tidal waters.
Disposal of dredged material other than from artificial waterways		
PO19 Dredged material is returned to **tidal water** where this is needed to maintain **coastal processes** and sediment volume.	No acceptable outcome is prescribed.	**Not applicable** No dredging will be undertaken as part of these works
PO20 Where it is not needed to maintain **coastal processes** and sediment volume, the quantity of **dredged material** disposed to **tidal water** is minimised through **beneficial reuse** or disposal on land.	No acceptable outcome is prescribed.	**Compliant** All excavated materials will be handled in accordance with relevant requirements and placed on land
All dredging and any disposal of dredged material in tidal water		

Performance outcomes	Acceptable outcomes	
PO21 All **dredging** and any disposal of **dredged material** in **tidal water** is: 1. demonstrated to be safe with regard to protection of the marine environment and by meeting the National Assessment Guidelines for Dredging 2009, Department of Environment and Energy, 2009, or later version; and supported by a monitoring and management plan that protects the marine environment and that complies with the National Assessment Guidelines for Dredging 2009, Department of Environment and Energy, 2009, or later version.	No acceptable outcome is prescribed.	**Not applicable** Dredging is not proposed in tidal waters.
Reclamation		
PO22 Development does not involve **reclamation** of land below **tidal water**, other than for the purposes of: 1. **coastal-dependent development, public marine development** or community infrastructure; or 2. strategic ports, priority ports, boat harbours or strategic airports and aviation facilities, in accordance with a statutory land use plan or master plan, where there is a demonstrated net benefit for the state or region and no feasible alternative exists; or **coastal protection work** or work necessary to protect **coastal resources** or **coastal processes**.	No acceptable outcome is prescribed.	**Not applicable** Reclamation is not proposed.

Table 8.2-3 Operational work which is not assessed by local government

Performance outcomes	Acceptable outcomes	Response
PO23 Works are located and designed such that they continue to operate safely during and following a **defined storm tide event**.	**AO23.1** Tidal work is designed and located in accordance with the Guideline: Building and engineering standards for tidal works, Department of Environment and Heritage Protection, 2017.	**Complies.** The development is designed to withstand a DSTE.

6.4 Reference Documents

Department of Environment and Energy 2009, National Assessment Guidelines for Dredging 2009

Department of Environment and Heritage Protection 2016, Environmental offsets framework documents

Department of Environment and Heritage Protection 2016, Guideline – SDAP State code 8: Coastal development and tidal works

Department of Environment and Heritage Protection 2017, Guideline: Building and engineering standards for tidal works

Department of State Development, Infrastructure and Planning 2014. Significant Residual Impact Guideline

6.5 Glossary of Terms

Artificial waterway see section 8 of the *Coastal Protection and Management Act 1995*.

Note: **Artificial waterway** means an artificial channel, lake or other body of water. An **artificial waterway** includes:

1. an access channel
2. an artificial channel that is formed because land has been reclaimed from **tidal water** and is intended to allow boating access to allotments on subdivided land
3. other artificial channels subject to the ebb and flow of the tide
4. any additions or alterations to an **artificial waterway**.

However, an **artificial waterway** does not include the following:

1. a swimming pool
2. an ornamental pond of no more than 5 000 square metres in area
3. a pond for aquaculture or for treating effluent
4. a freshwater storage reservoir for domestic water supply
5. a water storage facility situated on a natural watercourse and used for irrigation or other agricultural purposes
6. a part of a river, creek or stream in which water flows in a natural channel, whether artificially improved or not

7. a drain for carrying stormwater or other material
8. any of the following used for accessing port infrastructure if constructed in the area of a port for which a port authority or port operator is responsible:
    a. a navigation channel
    b. a harbour swing basin
    c. a berth pocket
    d. a berth approach or departure path.

Beach nourishment means the replenishment of a beach system using imported sediment to balance erosion losses or to re-establish a wider beach and dune system. It does not include the creation of a new beach.

Beneficial reuse means using **dredged material** for a purpose that provides social, economic or environmental benefits (or a combination of these). It includes **beach nourishment**, **reclamation**, environmental restoration purposes (such as restoring wetlands or nesting islands) and use on land for fill or construction purposes.

Category C areas means areas of high value regrowth vegetation classed as 'endangered' or 'of concern' under the *Vegetation Management Act 1999* that are shown on the regulated vegetation management map as **category C areas**.

Category R areas means regrowth watercourse and drainage feature areas under the *Vegetation Management Act 1999* that are shown on the regulated vegetation management map as **category R areas**.

Coastal building line see the *Coastal Protection and Management Act 1995*.

Note: **Coastal building line** means a line declared as a **coastal building line** under the *Coastal Protection and Management Act 1995*.

Coastal-dependent development:

1. means development that in order to function must be located in **tidal waters** or be able to access **tidal water**; and
2. may include, but is not limited to:
    a. industrial and commercial facilities such as ports, harbours and navigation channels and facilities, aquaculture involving marine species, desalination plants, tidal generators, **coastal protection works**, **erosion control structures, public marine development** and **beach nourishment**
    b. tourism facilities for marine (boating) purposes

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c. community facilities and sporting facilities which require access to **tidal water** in order to function, such as surf clubs, marine rescue, rowing and sailing clubs; or

d. co-located residential and tourist uses that are part of an integrated development proposal (e.g. mixed use development) incorporating a marina, if these uses are located directly landward of the marina and appropriately protected from natural hazards; but

3. does not include:

a. residential development, including canal development, as the primary use

b. waste management facilities, such as landfills, sewerage treatment plants; or

c. transport infrastructure, other than for access to the coast.

Coastal erosion means the loss of land or the removal of beach or dune sediments by wave action, wind action, tidal currents or water flows or by permanent inundation due to **sea level rise**.

Coastal management district see the Planning Regulation 2017.
Note: **Coastal management district** means a **coastal management district** under the *Coastal Protection and Management Act 1995*, other than an area declared under section 54(2) of that Act.

Coastal processes means the natural processes of the coast, including:

1. sediment transport to and along the coast
2. wind, waves, tides and currents which transfer energy to the coast and drive sediment transport
3. fluctuations in the location and form of landforms and the foreshore and associated ecosystems from sediment transport (erosion and land building); and
4. changes in sea level; ecological processes (including growth and spread of native plants); and the natural water cycle (for example coastal wetlands' role in filtration and flood mitigation).

Coastal protection work means any permanent or periodic work undertaken primarily to manage the impacts of **coastal erosion** or **storm tide inundation**, including the use of **erosion control structures** and altering **coastal processes** such as sediment transport.

Coastal resources means the natural resources of the coastal zone. It includes natural and physical features and landforms, **coastal processes**, vegetation, wildlife, the marine environment, quarry material, soil, water and air.

DA mapping system means the mapping system containing the Geographic Information System mapping layers kept, prepared or sourced by the state that relate to development assessment and matters of interest to the state in assessing development applications.
Note: The **DA mapping system** is available on the department's website.

Defined storm tide event (DSTE) means the event, measured in terms of likelihood of reoccurrence, and associated inundation level adopted to manage the development of a particular area. The DSTE is equivalent to a one in 100 year average recurrence interval storm event incorporating:

1. **sea level rise**; and
2. an increase in cyclone intensity by 10 percent relative to maximum potential intensity.

Note: Where **storm tide inundation** levels have not been determined by a local study, the **defined storm tide event level** can be determined by reference to default **storm tide inundation** area mapping, as depicted in the **DA mapping system**. In these mapping layers, **storm tide inundation** is based on default values of 1.5 metres above highest astronomical tide (HAT) for South East Queensland and 2.0 metres above HAT for the remainder of the state. Where required, the storm tide level can be related back to Australian Height Datum by reference to the Queensland Tide Tables.

Defined storm tide event level means the peak water level reached during a **defined storm tide event**.

Dredged material means mud, sand, coral, shingle, gravel, clay, earth and other material removed by **dredging** from the bed in **tidal water**. Dredged material includes **dredge spoil**, quarry material where it is removed from **tidal water** as a commercial product and sand dredged for **beach nourishment**.

Dredging means the mechanical removal of **dredged material** from below **tidal water**. It excludes minor adjustments to the bed surface to level troughs and peaks and where bed material is only redistributed locally (bed levelling).

Dry-land marina means a marina created by the excavation of land above the high water mark.

Environmental value see the *Environmental Protection Act 1994*.
Note: **Environmental value** means:
1. a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety; or
2. another quality of the environment identified and declared to be an **environmental value** under an environmental protection policy or regulation.

The Environmental Protection (Water) Policy 2009 states the **environmental values** of waters.

Erosion control structure means a structure designed to protect land or to permanently alter sediment transport processes and includes a structure such as a seawall or revetment (rock walls), groyne, artificial reef, or breakwater.

Erosion prone area means an area declared to be an **erosion prone area** under section 70(1) of the *Coastal Protection and Management Act 1995*.

Note: The **erosion prone area** is indicatively shown on the **DA mapping system**.
Erosion prone areas are identified in accordance with the methodology set out in the Coastal Hazard Technical Guide, Department of Environment and Heritage Protection, 2013 and use the following factors to account for the projected impacts of climate change by the year 2100:

1. a **sea level rise** factor of 0.8 metres
2. an increase in the maximum cyclone intensity by 10 percent.

Essential community infrastructure includes:

1. emergency services infrastructure
2. emergency shelters
3. police facilities
4. hospitals and associated facilities
5. stores of valuable records or heritage items
6. infrastructure forming part of the electricity transmission grid or supply network
7. communications facilities
8. sewerage treatment plants
9. water treatment plants.

Marine access purpose means a structure in **tidal water** used to facilitate vessel access for people between land and a **navigable waterway**. This includes jetties, pontoons and boat ramps but excludes decks and boardwalks.

Matters of state environmental significance see schedule 2 of the Environmental Offsets Regulation 2014.
Note: **Matters of state environmental significance** are **prescribed environmental matters** under the Environmental Offsets Regulation 2014 that require an **offset** when a prescribed activity will have a **significant residual impact** on the matter. A **matter of state environmental significance** is any of the following matters:

1. regional ecosystems under the *Vegetation Management Act 1999* that:
    a. are endangered regional ecosystems
    b. are of concern regional ecosystems
    c. intersect with a wetland shown on the vegetation management wetlands map
    d. contain areas of essential habitat shown on the essential habitat map for an animal that is endangered wildlife or vulnerable wildlife or a plant that is endangered wildlife or vulnerable wildlife

e. are located within the defined distances stated in the Environmental Offsets Policy 2014 from the defining banks of a relevant watercourse or drainage feature as shown on the vegetation management watercourse and drainage feature map
f. contain remnant vegetation and are areas of land determined to be required for ecosystem functioning ('connectivity areas')

2. wetlands in a wetland protection area or wetlands of high ecological significance shown on the Map of referable wetlands under the Environmental Protection Regulation 2008
3. wetlands and watercourses in high ecological value waters as defined in schedule 2 of the Environmental Protection (Water) Policy 2009
4. designated precincts in strategic environmental areas under the Regional Planning Interests Regulation 2014
5. threatened wildlife under the *Nature Conservation Act 1992* and special least concern animals under the Nature Conservation (Wildlife) Regulation 2006
6. protected areas under the *Nature Conservation Act 1992* excluding coordinated conservation areas
7. highly protected zones of state marine parks under the *Marine Parks Act 2004*
8. declared fish habitat areas under the *Fisheries Act 1994*
9. waterways that provide for fish passage under the *Fisheries Act 1994* if the construction, installation or modification of waterway barrier works carried will limit the passage of fish along the waterway
10. marine plants under the *Fisheries Act 1994*
11. legally secured **offset** areas.

Navigable waterway means waters with a sufficient depth and width to allow safe passage by all vessel sizes and types that frequently use the area.

Offset means environmental **offset** under the *Environmental Offsets Act 2014*.
Note: Environmental **offset** means an activity undertaken to counterbalance a **significant residual impact** of a prescribed activity on a **prescribed environmental matter**, delivered in accordance with the Environmental offsets framework, Department of Environment and Heritage Protection, 2016. The **prescribed environmental matters** assessed under the SDAP are **matters of state environmental significance**.

Prescribed environmental matters see the Environmental Offsets Regulation 2014.
Note: A **prescribed environmental matter** is any species, ecosystem or other similar matter protected under Queensland legislation for which an environmental **offset** may be provided. A **prescribed environmental matter** may be a matter of national, state or local environmental significance, however, assessment criteria in the SDAP only relate to **matters of state environmental significance**. Each of the **prescribed environmental matters** are listed under the Environmental Offsets Regulation 2014.

Prescribed water contaminants see the *Environmental Protection Act 1994*.
Note: See schedule 9 of the Environmental Protection Regulation 2008 for a list of **prescribed water contaminants**.

Private marine development means a work for a non-commercial purpose attached to private land and extending over abutting **tidal water**.

Public marine development means development for public use that requires location in or adjacent to

tidal water to function.

Reclamation see the *Coastal Protection and Management Act 1995*.
Note: **Reclamation** of land under **tidal water** means raising the land above the high water mark, whether gradually and imperceptibly or otherwise, by carrying out works, including **dredging** and the depositing of solid material.

Redevelopment means development that affects permanent built structures on an already developed site. Redevelopment includes the expansion of a building footprint or addition of a structure, reconstruction or remodelling an exterior, demolition and replacement of existing structures.

Sea level rise means an increase in sea level caused by global warming due to climate change. Sea level rise is projected to be 0.8 metres from the present day to 2100.
Note: **Sea level rise** projections based on the best available science are prepared by the Intergovernmental Panel on Climate Change.

Significant residual impact see the *Environmental Offsets Act 2014.*
Note: **Significant residual impact** is an impact, whether direct or indirect, of a prescribed activity on all or part of a **prescribed environmental matter** that:

1. remains, or will or is likely to remain, (whether temporarily or permanently) despite on-site mitigation measures for the prescribed activity
2. is, or will or is likely to be, significant.

Guidance for determining if a prescribed activity will have a **significant residual impact** on a **matter of state environmental significance** is provided in the Significant Residual Impact Guideline, Department State Development, Infrastructure and Planning, 2014.

State coastal land see the *Coastal Protection and Management Act 1995.*

Note: **State coastal land** means land in a **coastal management district** other than land that is:

1. freehold land, or land contracted to be granted in fee simple by the state; or
2. a state forest or timber reserve under the *Forestry Act 1959*; or
3. in a watercourse or lake as defined under the *Water Act 2000*; or
4. subject to a lease or licence issued by the state.

State coastal land includes land that is, or is at any time, covered by **tidal water**.

Storm tide inundation means temporary inundation of land by abnormally high ocean levels caused by cyclones and severe storms.

Temporary, readily relocatable or able to be abandoned means a structure that, if threatened by **coastal erosion**, will be relocated, removed or allowed to be lost rather than protected from the impacts because it is:

1. of low economic value; and
2. is capable of being disassembled, is easily removed, or loss by erosion is of low consequence; and
3. is not an intrinsic part of infrastructure or will have high social value or need; or
4. intended to remain in place for only a short period and then removed, whether or not it is threatened by **coastal erosion**.

Tidal prism volume means the volume of water for a specified area between the mean high water springs and mean low water springs tidal planes, or the volume of water leaving an estuary during the ebb tide.

Tidal water see the *Coastal Protection and Management Act 1995*.
Note: **Tidal water** means:

1. the sea and any part of a harbour or watercourse ordinarily within the ebb and flow of the tide at spring tides; or
2. the water downstream from a downstream limit as defined under the *Water Act 2000*.

Water quality objectives means the numerical concentration limits, mass or volume limits per unit of time or narrative statements of indicators established for waters to enhance or protection the **environmental values** for those waters set out in:

1. schedule 1 of the Environmental Protection (Water) Policy 2009, for water mentioned in the policy; or
2. otherwise, the Queensland Water Quality Guide

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APPENDIX L
STATE PLANNING POLICY



Assessment Benchmarks – Water Quality

The performance outcomes for the Southern Redland Bay WWTP development has been assessed against benchmarks in Part E of SPP State Interest for Water Quality Compliance and Water quality Assessment Benchmarks.

STATE PLANNING POLICY - WATER QUALITY COMPLIANCE

Item	Comment
Development facilitates the protection or enhancement of environmental values and the achievement of water quality objectives for Queensland waters.	This has been demonstrated in Sections 9, 10 and 11 of this assessment report.
Land zones for urban purposes are located in areas that avoid or minimize the disturbance to: ■ High risk soils ■ High ecological value aquatic ecosystems ■ Groundwater dependent ecosystems ■ Natural drainage lines and landform features	These items have been considered and assessed for compliance both within this report and in the following documents: ■ Report on Acid Sulphate Soils Investigation, Douglas Partners ■ Ecological Assessment Report (Flora and Fauna) - MNES and MSES;
Development is located, designed, constructed, and operated to avoid or minimize adverse impacts on environmental values of receiving waters arising from: ■ Altered stormwater quality and hydrology ■ Wastewater (other than contaminated stormwater and sewage) ■ The creation or expansion of non-tidal artificial waterways ■ The release and mobilization of nutrients and sediments	This has been demonstrated in Sections 9, 10 and 11 of this assessment report.
At the construction phase, development achieves the applicable stormwater management design objectives in table A (Appendix 2) of SPP (2017).	Addressed in responses to table A (Appendix 2) of SPP (2017).
At the post-construction phase, development: ■ Achieves the applicable stormwater management design objectives on-site, as identified in table B (Appendix 2) of SPP (2017), or ■ Achieves an alternative locally appropriate solution off-site that achieves an equivalent or improved water quality outcome to the relevant stormwater management design objectives in table B (Appendix 2) of SPP (2017).	Addressed in responses to in table B (Appendix 2) of SPP (2017)

Item	Comment
Development in water resource catchments and water supply buffer areas avoids potential adverse impacts on surface waters and groundwaters to protect drinking water supply environmental values.	The Site does not exist in the water resource catchment areas or the water supply buffer areas, therefore drinking water EVs are not applicable to this development. However, impacts on the surface waters and groundwaters have been appropriately considered in Sections 8, 9 and 10 of this assessment report.

ASSESSMENT BENCHMARKS – WATER QUALITY

Performance Outcomes	Response
For **receiving waters**, a development application for: ■ Operational works for an urban purpose that involves disturbing a land area 2,500 meters or greater in size	This assessment is a supporting document to the development application.
For the **development**, assessment benchmarks are as follows: Development is located, designed, constructed and operated to avoid or minimise adverse impacts on environmental values arising from: ■ Altered stormwater quality and hydrology ■ Wastewater ■ The release and mobilization of nutrients and sediments.	This has been demonstrated in Sections 8, 9 and 10 of this assessment report.
Development achieves the applicable stormwater management design objectives outlined in tables A and B (Appendix 2) of SPP (2017).	Addressed in State Planning Policy: Appendix 2 – Stormwater Management Design Objectives
Development achieves the applicable stormwater management design objectives outlined in tables A and B (Appendix 2) of SPP (2017).	Addressed in State Planning Policy: Appendix 2 – Stormwater Management Design Objectives

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STATE PLANNING POLICY: APPENDIX 2 – STORMWATER MANAGEMENT DESIGN OBJECTIVES

Table A: Construction phase – stormwater management design objectives

The design objectives for the construction phase in Table A of SPP Appendix 2 apply to all climatic regions. The responses to the desired outcomes are addressed in below

TABLE A - PART 1: CONSTRUCTION PHASE – STORMWATER MANAGEMENT DESIGN OBJECTIVES*

Issue	Desired Outcome	Response
Drainage Control	■ Manage stormwater flows around or through areas of exposed soil to avoid contamination. ■ Manage sheet flows in order to avoid or minimise the generation of rill or gully erosion. ■ Provide stable concentrated flow paths to achieve the construction phase stormwater management design objectives for temporary drainage works (part 2). ■ Provide emergency spillways for sediment basins to achieve the construction phase stormwater management design objectives for emergency spillways on temporary sediment basins (part 3).	All drainage control design objectives for the construction phase will be appropriately considered by the development contractor and be incorporated in the site-based management plan.
Erosion Control	■ Stage clearing and construction works to minimise the area of exposed soil at any one time. ■ Effectively cover or stabilise exposed soils prior to predicted rainfall. ■ Prior to completion of works for the development, and prior to removal of sediment controls, all site surfaces must be effectively stabilised** using methods which will achieve effective short-term stabilisation.	All erosion control design objectives for the construction phase will be appropriately considered by the development contractor and be incorporated in the site-based management plan.
Sediment Control	■ Direct runoff from exposed site soils to sediment controls that are appropriate to the extent of disturbance and level of erosion risk. ■ All exposed areas greater than 2500 metres2 must be provided with sediment controls which are designed, implemented and maintained to a standard which would achieve at least 80% of the average annual runoff volume of the contributing catchment treated (i.e. 80% hydrological effectiveness) to 50mg/L Total Suspended Solids (TSS) or less, and pH in the range (6.5–8.5).	All sediment control design objectives for the construction phase will be appropriately considered by the development contractor and be incorporated in the site-based management plan.
Litter, hydrocarbons and contaminants	■ Remove gross pollutants and litter. ■ Avoid the release of oil or visible sheen to released waters. ■ Dispose of waste containing contaminants at authorised facilities.	All objectives for the construction phase will be appropriately considered by the development contractor and be incorporated in the site-based management plan.

Issue	Desired Outcome	Response
Waterway stability and flood flow management	■ Where measures are required to meet post-construction waterway stability objectives (specified in table B), these are either installed prior to land disturbance and are integrated with erosion and sediment controls, or equivalent alternative measures are implemented during construction. ■ Earthworks and the implementation of erosion and sediment controls are undertaken in ways which ensure flooding characteristics (including stormwater quantity characteristics) external to the development site are not worsened during construction for all events up to and including the 1 in 100 year ARI (1% AEP).	All objectives for the construction phase will be appropriately considered by the development contractor and be incorporated in the site-based management plan. Also see Engineering Plans by KN Group for further details.
*Note: Drainage, erosion and sediment controls should be appropriate to the risk posed by the activity for the relevant climatic region e.g. considering the potential soil loss rate, monthly erosivity or average monthly rainfall. **Note: An effectively stabilised surface is defined as one that does not, or is not likely to result in visible evidence of soil loss caused by sheet, rill or gully erosion or lead to sedimentation water contamination.		

TABLE A - PART 2: CONSTRUCTION PHASE – STORMWATER MANAGEMENT DESIGN OBJECTIVES FOR TEMPORARY DRAINAGE WORKS

Temporary drainage works	Anticipated operation design life and minimum design storm event			Response
Duration	< 12 months	12–24 months	> 24 months	Will be appropriately addressed by the development contractor prior to construction.
Drainage structure	1 in 2 year ARI/39% AEP	1 in 5 year ARI/18% AEP	1 in 10 year ARI/10% AEP	Will be appropriately addressed by the development contractor prior to construction.
Where located immediately up-slope of an occupied property that would be adversely affected by the failure or overtopping of the structure		1 in 10 year ARI/10% AEP		Not applicable
Culvert crossing		1 in 1 year ARI/63% AEP		Will be appropriately addressed by the development contractor prior to construction.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

TABLE A - PART 3: CONSTRUCTION PHASE – STORMWATER MANAGEMENT DESIGN OBJECTIVES FOR EMERGENCY SPILLWAYS ON TEMPORARY SEDIMENT BASINS

Drainage structure	Anticipated operation design life and minimum design storm event			Response
Duration	< 3 months	3–12 months	> 12 months	Will be appropriately addressed by the development contractor prior to construction.
Emergency spillways on temporary sediment basins	1 in 10 year ARI/10% AEP	1 in 20 year ARI/5% AEP	1 in 50 year ARI/2% AEP	Will be appropriately addressed by the development contractor prior to construction.

Note: Refer to IECA 2008 Best Practice Erosion and Sediment Control (as amended) for details on the application of the Construction Phase requirements. Advice should be obtained from a suitably qualified person e.g. Certified Practitioner in Erosion and Sediment Control, or Registered Professional Engineer Queensland, with appropriate knowledge and experience in erosion and sediment control design and implementation.

Table B: Post construction phase – stormwater management design objectives

The design objectives for the post construction phase in Table B of SPP Appendix 2 apply to the following:

- A material change of use for an urban purpose that involves premises 2500 metres2 or greater in size and:
  - will result in six or more dwellings; or
  - an impervious area greater than 25 per cent of the net developable area.
- Reconfiguring a lot for urban purposes that involves premises 2500 metres2 or greater in size and will result in six or more lots.

The design objectives for the post construction phase are **not applicable** to the proposed development.

R01v05_20020099_Southern_Redland_Bay_Stage_3_Assessments

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