N O T I C E O F M E E T I N G

W A T E R , W A S T E A N D S E W E R A D V I S O R Y C O M M I T T E E M E E T I N G

A Water, Waste and Sewer Advisory Committee Meeting of Byron Shire Council will be held as follows:

Venue	**Conference Room, Station Street, Mullumbimby**
Date	**Thursday, 10 October 2019**
Time	**2.00pm**

Phil Holloway
Director Infrastructure Services

I2019/1600
Distributed 03/10/19
Amended 10/10/19 (Report 4.2 Att 3 and 4)

CONFLICT OF INTERESTS

What is a "Conflict of Interests" - A conflict of interests can be of two types:
Pecuniary - an interest that a person has in a matter because of a reasonable likelihood or expectation of appreciable financial gain or loss to the person or another person with whom the person is associated.
Non-pecuniary – a private or personal interest that a Council official has that does not amount to a pecuniary interest as defined in the Code of Conduct for Councillors (eg. A friendship, membership of an association, society or trade union or involvement or interest in an activity and may include an interest of a financial nature).
Remoteness – a person does not have a pecuniary interest in a matter if the interest is so remote or insignificant that it could not reasonably be regarded as likely to influence any decision the person might make in relation to a matter or if the interest is of a kind specified in the Code of Conduct for Councillors.
Who has a Pecuniary Interest? - a person has a pecuniary interest in a matter if the pecuniary interest is the interest of the person, or another person with whom the person is associated (see below).
Relatives, Partners - a person is taken to have a pecuniary interest in a matter if:

- The person's spouse or de facto partner or a relative of the person has a pecuniary interest in the matter, or
- The person, or a nominee, partners or employer of the person, is a member of a company or other body that has a pecuniary interest in the matter.

N.B. "Relative", in relation to a person means any of the following:
(a) the parent, grandparent, brother, sister, uncle, aunt, nephew, niece, lineal descends or adopted child of the person or of the person's spouse;
(b) the spouse or de facto partners of the person or of a person referred to in paragraph (a)

No Interest in the Matter - however, a person is not taken to have a pecuniary interest in a matter:

- If the person is unaware of the relevant pecuniary interest of the spouse, de facto partner, relative or company or other body, or
- Just because the person is a member of, or is employed by, the Council.
- Just because the person is a member of, or a delegate of the Council to, a company or other body that has a pecuniary interest in the matter provided that the person has no beneficial interest in any shares of the company or body.

Disclosure and participation in meetings

- A Councillor or a member of a Council Committee who has a pecuniary interest in any matter with which the Council is concerned and who is present at a meeting of the Council or Committee at which the matter is being considered must disclose the nature of the interest to the meeting as soon as practicable.
- The Councillor or member must not be present at, or in sight of, the meeting of the Council or Committee:
  (a) at any time during which the matter is being considered or discussed by the Council or Committee, or
  (b) at any time during which the Council or Committee is voting on any question in relation to the matter.

No Knowledge - a person does not breach this Clause if the person did not know and could not reasonably be expected to have known that the matter under consideration at the meeting was a matter in which he or she had a pecuniary interest.
Non-pecuniary Interests - Must be disclosed in meetings.
There are a broad range of options available for managing conflicts & the option chosen will depend on an assessment of the circumstances of the matter, the nature of the interest and the significance of the issue being dealt with. Non-pecuniary conflicts of interests must be dealt with in at least one of the following ways:

- It may be appropriate that no action be taken where the potential for conflict is minimal. However, Councillors should consider providing an explanation of why they consider a conflict does not exist.
- Limit involvement if practical (eg. Participate in discussion but not in decision making or vice-versa). Care needs to be taken when exercising this option.
- Remove the source of the conflict (eg. Relinquishing or divesting the personal interest that creates the conflict)
- Have no involvement by absenting yourself from and not taking part in any debate or voting on the issue as of the provisions in the Code of Conduct (particularly if you have a significant non-pecuniary interest)

RECORDING OF VOTING ON PLANNING MATTERS

Clause 375A of the Local Government Act 1993 – Recording of voting on planning matters

(1) In this section, **planning decision** means a decision made in the exercise of a function of a council under the Environmental Planning and Assessment Act 1979:
  (a) including a decision relating to a development application, an environmental planning instrument, a development control plan or a development contribution plan under that Act, but
  (b) not including the making of an order under that Act.
(2) The general manager is required to keep a register containing, for each planning decision made at a meeting of the council or a council committee, the names of the councillors who supported the decision and the names of any councillors who opposed (or are taken to have opposed) the decision.
(3) For the purpose of maintaining the register, a division is required to be called whenever a motion for a planning decision is put at a meeting of the council or a council committee.
(4) Each decision recorded in the register is to be described in the register or identified in a manner that enables the description to be obtained from another publicly available document, and is to include the information required by the regulations.
(5) This section extends to a meeting that is closed to the public.

BUSINESS OF MEETING

1. APOLOGIES

2. DECLARATIONS OF INTEREST – PECUNIARY AND NON-PECUNIARY

3. ADOPTION OF MINUTES FROM PREVIOUS MEETINGS

3.1 Water, Waste and Sewer Advisory Committee Meeting held on 13 June 2019
3.2 Extraordinary Water, Waste and Sewer Advisory Committee Meeting held on 29 August 2019

4. STAFF REPORTS

Infrastructure Services

STAFF REPORTS - INFRASTRUCTURE SERVICES

Report No. 4.1 **Inflow and Infiltration**
Directorate: Infrastructure Services
Report Author: Cameron Clark, Manager Utilities
File No: I2019/1511

Summary:

The Mullumbimby three month flow metering trial has been completed and has provided baseline I/I data for future projects. It has also verified the results obtained from the SCADA upgrade performed late 2018.

Interflows have begun inspection works within Mullumbimby to identify points of inflow in the sewerage system. The outcome will be a report listing Council sewerage and stormwater assets current condition and recommendation of repair, reline or replace. It will also identify areas of illegal connections into the sewerage system which contribute to inflow.

A Community Survey for Mullumbimby residents will be issued in the near future to gain further understanding of the impact I/I has within the community.

RECOMMENDATION:

That the Committee note the report

Attachments:

1 24.2015.79.1 - EDS - FLOW METER - Mullumbimby Flow Monitoring_2018_2019.pdf, E2019/40917 , page 8⇩
2 24.2015.79.1 - DRAFT CEMP - CommunicationEngagementPlan_InflowInfiltration_WSUD, E2019/40846 , page 24⇩
3 24.2015.79.1 - AWC - Summary for Wastewater Steering May19, E2019/40849 , page 33⇩

REPORT

The Mullumbimby Inflow and Infiltration investigation in Mullumbimby has identified areas of the sewerage network which receive high levels of inflow and infiltration. These levels have since been verified from flow metering performed by Environmental Data Services (EDS).

Interflow Pty Ltd has begun pressure cleaning and CCTV inspections of the sewerage and stormwater systems within the worst affected areas to located points of inflow. Depending on the outcome of these inspections, smoke testing may be required. At the completion of this investigation, it's anticipated that Council shall have a report which documents Council assets which need to be relined, rehabilitated or replaced. It will also indicate locations of properties which have illegal stormwater connections into Council's sewerage network; this then becomes a compliance matter.

The initial version of the Communications Engagement and Management Plan (CEMP) for this project has been drafted and provided to Council's communication team. As outlined in this document, Council will be issuing a survey for residents within the Mullumbimby area to obtain feedback of I/I issues. This survey shall be reviewed by the Mullumbimby Residents Association prior to be issued.

The previous SCADA upgrade in Mullumbimby which identified areas of high I/I was proven correct from recent flow metering. As such, this SCADA upgrade is being rolled out to all SPS sites within the Byron Shire to begin investigation phase for other catchments.

Environmental Data Services (EDS)

Refer to Attachment #1

Tim Fleming from EDS has provided his report (dated 21st May 2019) for the flow monitoring trial within Mullumbimby. This report confirms levels of infiltration and inflow within the Mullumbimby catchment, in particular the high level of inflow within the Mullumbimby CBD area. The results from this trial shall provide baseline flow rates for sections of the sewerage network, which can be compared against for future pilot projects.

Interflow

Interflow Pty Limited have begun cleaning and investigation of Council's sewer and stormwater assets within the Mullumbimby CBD area starting 27th May 2019. The CBD area (SPS4001 catchment) has been identified as having high levels of inflow as per SCADA and flow meter results. The scope of works include:-

- 97 Sewer manholes.
- 5,310m of 150mm sewer pipelines.
- 23 stormwater manholes.
- 2,526 stormwater mains of various sizes up to 750mm.
- Capture the condition of the cleaned Assets by way of CCTV camera and assess rehabilitation.
- Provide Council with a Condition Assessment Report of the assets including pipelines and maintenance holes in accordance with WSA05-2008 Conduit Inspection Reporting Code of Australia.
- Provide in this report at the completion of the works; recommendations to council for repair or renewal.

Communications Engagement Management Plan + Community Survey

Refer to Attachment #2

A draft Communications Engagement and Management Plan (CEMP) outlines the communication strategies and methods that will be used to promote community and stakeholder awareness, cooperation and engagement in the I&I project, Water Sensitive Urban Design and in reducing residential water use to help reduce inflow and infiltration into the sewerage system.

Key communication tasks for the I&I project include:-

- Online and postal survey for Mullumbimby residents to gain further understanding of the impact I/I has within the community;
- Dedicated project page on Council website as the key information resource for community;
- Social media and community newsletter notices to provide timely updates; and
- Use of community ambassadors to promote positive engagement in the project.

The results of the survey will assist in identifying high risk areas of flooding or sources of inflow and infiltration. They will also identify the level of community interest in the I&I issue and assist Council to create relevant and meaningful opportunities for the community to engage, such as the water sensitive urban design pilot projects.

The overall aims of the CEMP are to keep the community informed while encouraging positive engagement in the I&I project.

Summary of the communications activities to date for Reducing Stormwater in Sewer project (I&I):

- A community survey went out to approximately 1100 residences in Mullumbimby and online. It was open for 2 weeks.
- Advertising was via local print media (Echo and News) and Council social media.
- 163 responses have been received by Council. This is almost 15% response rate – which is considered at the higher end of average (average is 10-15 %.)
- The data is currently being analysed and cross referenced with existing data to identify priority areas and issues.
- Only one negative response from community was received re the survey process. The response questioned the value of the survey and noted that a physical assessment would provide a more objective outcome. The visual assessments were later undertaken as part of this project. The response was acknowledged via the Residents Association.
- A database of 95 residents has now been established for future comms on this project (direct subscription).
- The project team liaised with the Mullumbimby Residents Association prior to the survey being released and will continue to do so as a main stakeholder.
- There is a project page on Your Say website and Council's website where a number of short articles with further information on the project are available.
- A media release is planned for the near future to thank the community for their input.
- Social media, website, project webpage and direct mail (email and post database) will be standard comms methods.
- Future comms strategy is an awareness and education campaign about water sensitive urban design.

WSUD

Refer to Attachment #3

Summary of key points:

- Flow meters where installed within three manholes and continually monitored flows between the 1st of December 2018 and 1st of April 2019 to provide an understanding of how flows change in relation to daily usage, rainfall events and infiltration into the sewer network from high groundwater and cracks in the pipe network.

- An analysis of the issues relating to the sewer network and surface stormwater flows was also conducted to further understand and characterise the inflow and infiltration component. This included survey and site investigations within the three investigation areas Zone 1 south of Tyagarah Street, Zone 2 north of Burringbar Street adjacent to the river and Zone 3 within the centre of the town.

- Presently little to no management of stormwater in what would be considered a water sensitive approach occurs in Mullumbimby. This means that actions to include WSUD are likely to have significant benefit to both the amount of the local community and the environment. The adoption of WSUD within Mullumbimby will enhance the local environment while taking pressure off the town's sewage network.

- There are numerous locations where stormwater within laneways cannot physically reach the downstream stormwater network, meaning flooding occurs in even small storm events. Implementation of WSUD strategies can have a significant positive impact on reducing peak storm flows whilst reducing infiltration to sewer.

- Potential volumes which can be intercepted have been calculated using the 3-month ARI storm for Mullumbimby which corresponds to approximately a 40mm rainfall event. It should be recognised that storage and detention can be increased or reduced depending on available space and priority sub catchments where pressure on the sewer system is greatest. By capturing rainfall at the surface we prevent it from entering the sewer network and reduce the peak flows in the system.

- Monitoring of sewer flows has been ongoing since December 2018 and clearly demonstrates the increase in flow rates in the Mullumbimby sewer network when rainfall occurs.

- AWC has completed a detailed analysis of the opportunity to utilise WSUD urban design within Mullumbimby to reduce inflow and infiltration. This analysis confirms many opportunities to reduce inflow and infiltration of stormwater to sewer through the adoption of water sensitive urban design practices. Further detail is provided in the attached options analysis and plans.

These measures also provide secondary benefits including:

- Reduced demand for potable water.

- Creation of a greener and more sustainable town.

- Provision of shade and greenery throughout the town.

- The next stage of the project will develop a cost estimate for the strategy to then compare these costs with other options for reducing inflow and infiltration of stormwater to sewer.

EDS Environmental Data Services

EDS

Ref: PO333

Temporary Flow Gauging
Mullumbimby

Nov 2018 – April 2019

for

Byron Shire Council

Contact person for this project:

Tim Fleming
Project Manager
Work: (07) 5578 3622
Mobile: 0424 756 300
Email: tim@e-d-s.com.au
Web: www.e-d-s.com.au

EDS Head Office Location:

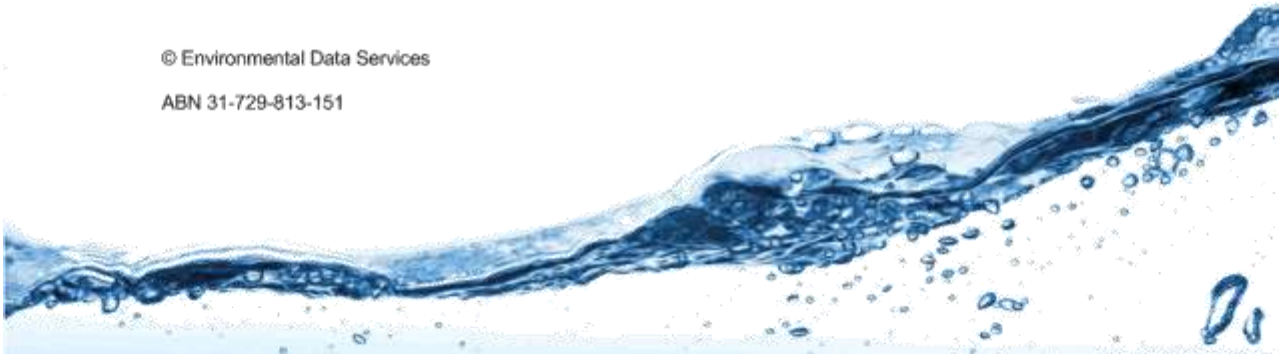
Queensland

Unit 12/17 Indy Court,
Nerang, Gold Coast
QLD, 4211

Commercial-in-Confidence

This proposal and the information, ideas, concepts, methodologies, technologies and other material it contains remain the intellectual property of Environmental Data Services. It is provided to prospective clients on a strict commercial-in-confidence basis, and at no time should any information be divulged to other parties.

ABN 31-729-813-151



1.0 BACKGROUND/SUMMARY

Environmental Data Services (EDS) were tasked with monitoring the flow at six manholes (selected by Byron Shire Council) within the Mullumbimby catchment.

The monitors were installed so that flow monitoring could commence before 1st December 2018. The aim was to measure flows during dry and wet weather to ascertain the affects of rain events on the system.

Three flow monitoring sites were selected on the Western side of the railway line, manholes A6, K1 & K2 and three on the Eastern side manholes AC1, AF2 & AP12.

This report is to summarise the results of this flow monitoring and is divided into two sections representing the western and eastern sides of the railway line.

Appendix A contains a series of plots as a visual representation of the data recorded.

2.0 WESTERN SIDE

Three flow monitors were installed on the Western side of the railway line at manholes K1, K2 & A6.

Manhole A6 is located in McGoughans Lane, K1 on the corner of Tyagarah & Gordons Streets., K2 on Barrington St.

Manhole A6 is located in McGoughans Lane.

Manhole Location

Inside Manhole

Upstream

Manhole K1 is located on the corner of Tyagarah &Gordons Streets.

Manhole Location

Inside Manhole

Upstream

Small flows were noted entering this manhole during installation and during subsequent dry weather visits.

Manhole K2 is located on Barrington St.

Manhole Location

Inside Manhole

Upstream

Small flows were noted entering this manhole during installation and during subsequent dry weather visits.

3.0 EASTERN SIDE

Three flow monitors were installed on the Eastern side of the railway line at manholes AC1, AF2 & AP12.

Manhole AC1 is located at 27 Ann St., AF2 Opposite 29 King St. in Ward Lane and AP12 in Harkness Lane.

Manhole AC1 is located at 27 Ann St.

Manhole Location

Inside Manhole

Upstream

Root infestations inside this manhole were removed before installation of the flow monitoring equipment. These roots may have caused problems upstream of this manhole during previous rain events.

EDS Environmental Data Services

Manhole AF2 is located opposite 29 King St. in Ward Lane.

Manhole Location

Inside Manhole

Upstream

Small flows were noted entering this manhole during installation and during subsequent dry weather visits.

Manhole AP12 is located in Harkness Lane.

Manhole Location

Inside Manhole

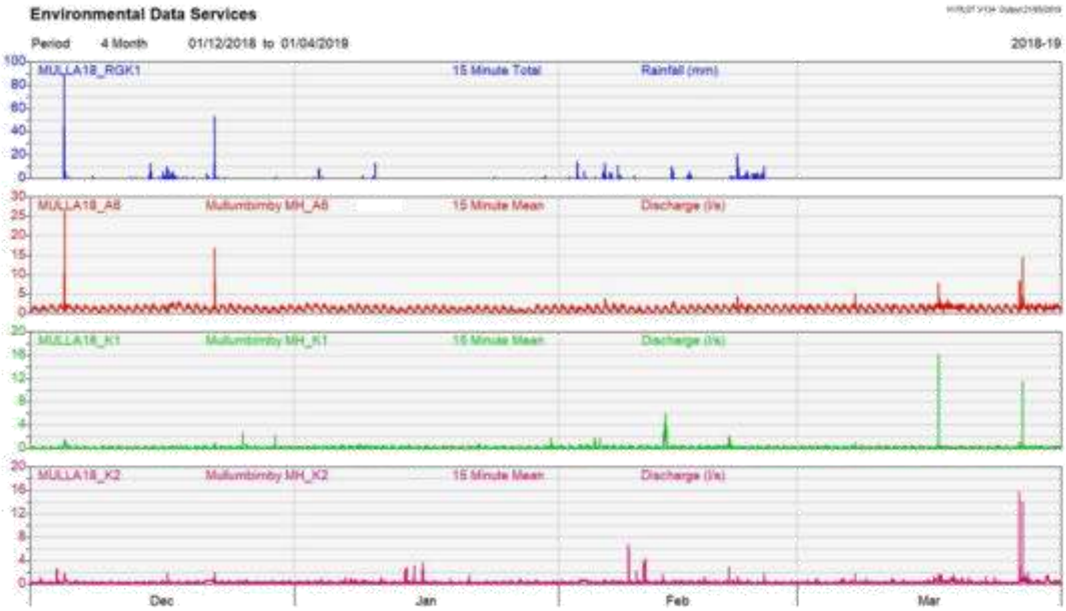
Upstream

Small flows were noted entering this manhole during installation and during subsequent dry weather visits.

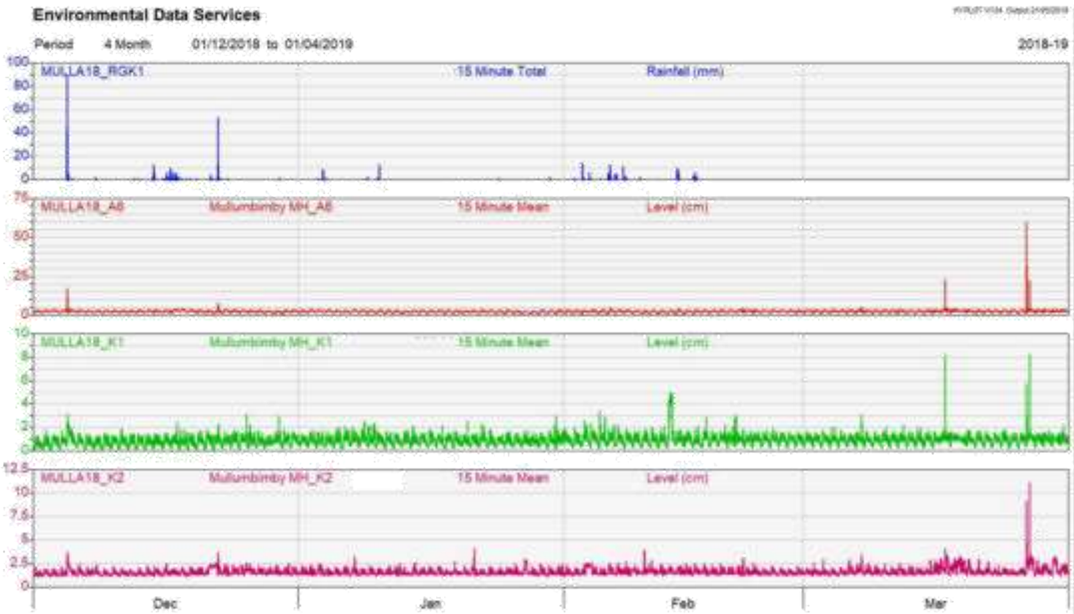
EDS Environmental Data Services

4.0 APPENDIX A

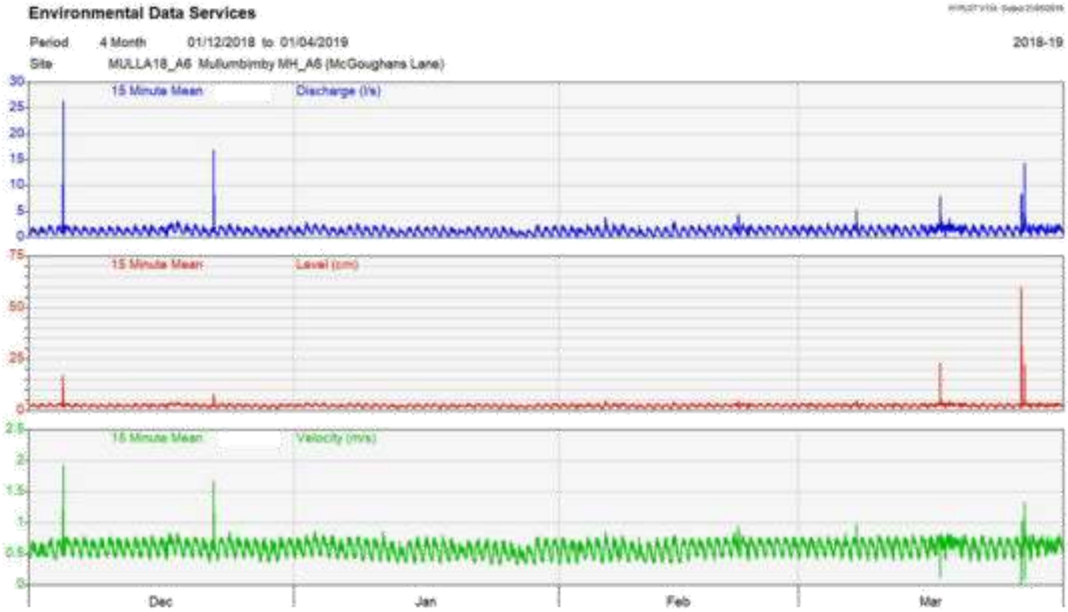
PLOTS



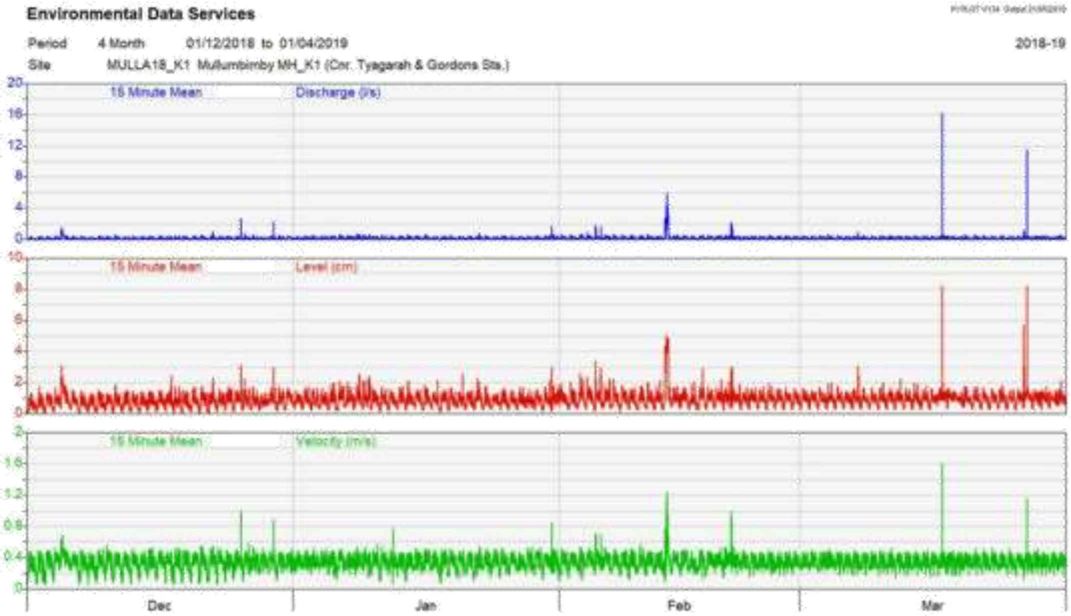
Plot of rainfall and flows at A6, K1 & K2



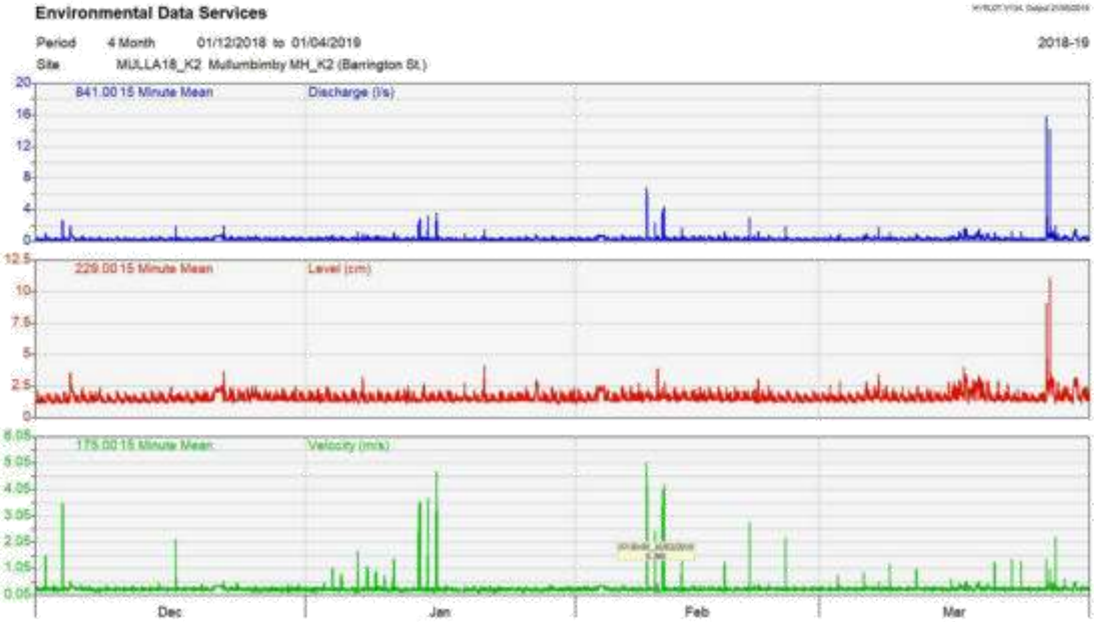
Plot of rainfall and depths at A6, K1 & K2



Plot of flow, depth and Velocity at A6



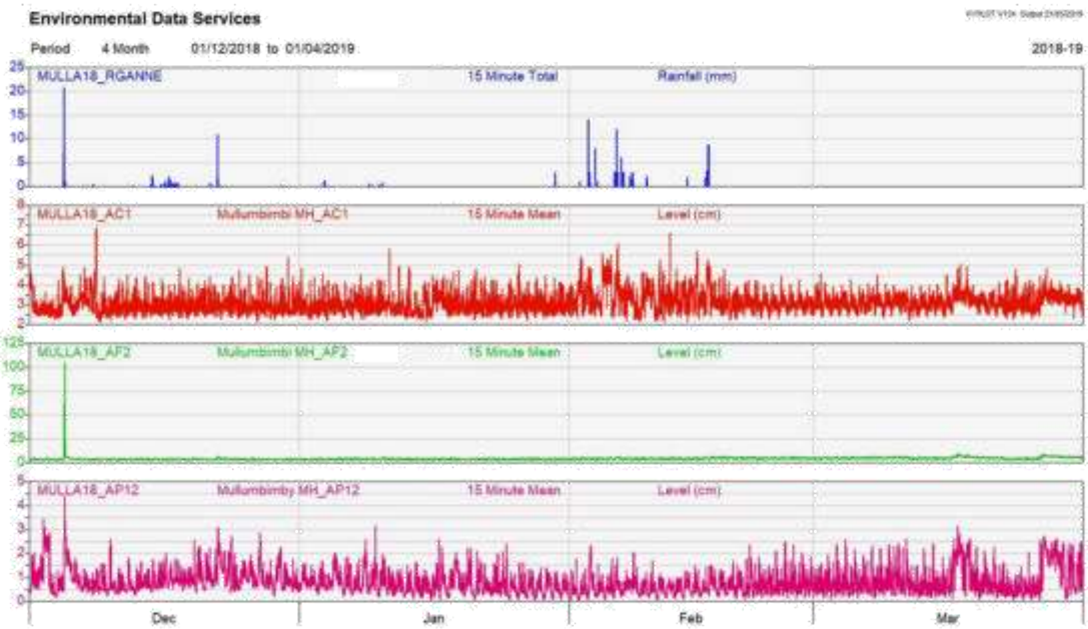
Plot of flow, depth and Velocity at K1



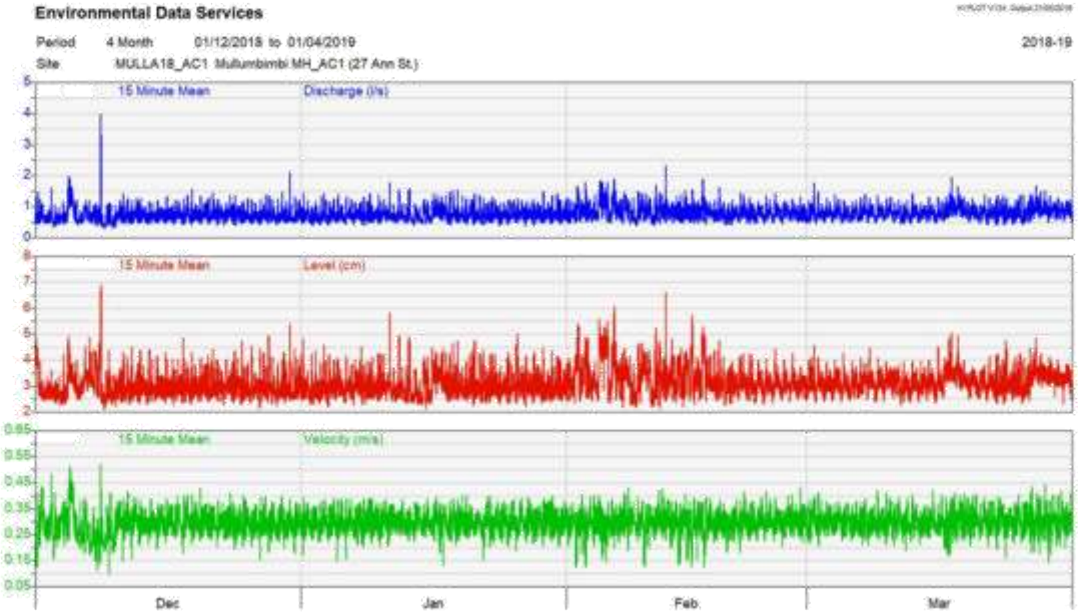
Plot of flow, depth and Velocity at K2

EDS Environmental Data Services

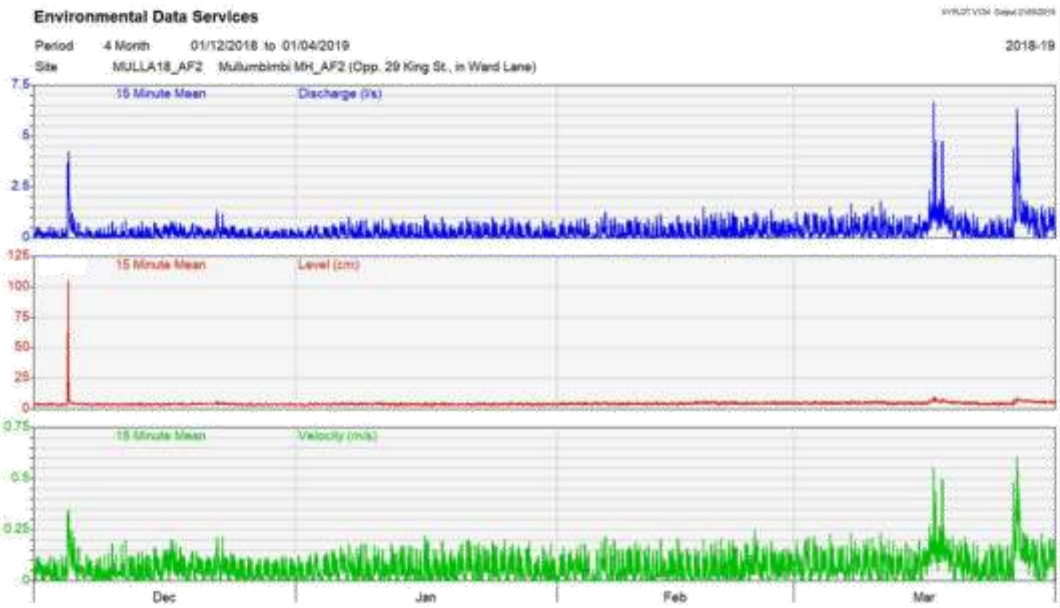
Plot of rainfall and flows at AC1, AF2 & AP12



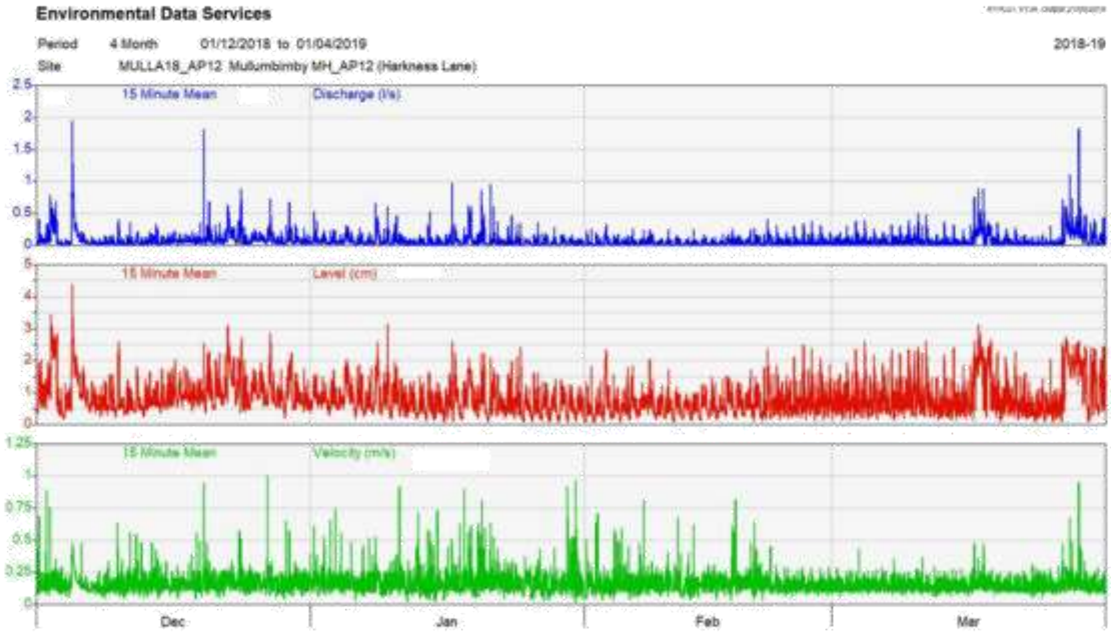
Plot of rainfall and depths at AC1, AF2 & AP12



Plot of flow, depth and Velocity at AC1



Plot of flow, depth and Velocity at AF2



Plot of flow, depth and Velocity at AP12

Rainfall summary

Day	Nov	Dec	Jan	Feb
1	[ ]			
2	[ ]			1
3	[ ]		2.2	34
4	[ ]	40.6	0.2	9
5	[ ]	16		
6	[ ]			27
7	[ ]	0.4		15
8	[ ]	0.8		9
9	[ ]		0.6	5
10	[ ]		1.6	
11	[ ]			
12	[ ]	0.4		
13	[ ]			
14	[ ]	0.6		1.87
15	[ ]	8.4		
16	[ ]	6		15.29
17	[ ]	14.6		[ ]
18	[ ]	1.4		[ ]
19	[ ]	0.2		[ ]
20	[ ]	0.2		[ ]
21	[ ]	1.6		[ ]
22	[ ]	15.4		[ ]
23	[ ]	0.4		[ ]
24	[ ]			[ ]
25	[ ]			[ ]
26	[ ]			[ ]
27				[ ]
28	11.6			[ ]
29		0.2		
30		0.2	4	
31				
Mean	2.9	3.46	0.28	7.32
Maximum	11.6	40.6	4	34
Minimum	0	0	0	0
Total	11.6	107.4	8.6	117.1
Wet Days	1	17	5	9
Missing Days	26	0	0	12

N.B the tag [ ] = Data not Recorded

Communication and Engagement Plan

Inflow and Infiltration Reduction Program, Mullumbimby

Project name	Inflow and Infiltration Reduction Program, Mullumbimby
Goals	To promote community and stakeholder awareness, cooperation and engagement in: 1. The Inflow and Infiltration Reduction program, specifically in the town of Mullumbimby. 2. Water Sensitive Urban Design to help reduce inflow and infiltration into the sewerage system. 3. Reducing residential water use to reduce demand on local water supply and minimise water waste into the sewerage system.
When	**STAGE 1: December 2018 – April 2019** • Drop-in information session (Tuesday 11 December 2018, 5-7pm) Advertise information session on Facebook and via newspapers • Dedicated page on Council website • Fact sheets for I/I and WSUD **STAGE 2: May – June 2019** • FAQs for Mullumbimby residents and Council website • Community survey (online and print) • Councillor brief • Mullumbimby Residents Association brief • Community newsletters • Local print media, editorial (Echo, Byron News, Northern Star) • Social media (Council Facebook page) • Bang the Table forum

	STAGE 3: June 2019 – August 2019 - Tbc after consultation with the Water Waste and Sewer Advisory Committee. • Media releases on pilot projects • Video and animation for website • Water Sensitive Urban Design printed flyers and downloadable docs for Council website • DIY rainwater garden kits/video series • Local ambassadors
Background	Byron Shire Council is committed to reducing inflow and infiltration into its sewerage network. The Inflow and Infiltration Reduction Program will look at improvement to both the stormwater and sewerage networks in Mullumbimby. Council will conduct flow monitoring of the sewerage network to better understand how it operates during rainfall events. The community will be encouraged to: 1. Inspect their premises, update old plumbing and assist Council with any inspections; 1. Reduce water consumption and waste; and 2. Adopt water sensitive urban design practices to assist Council in reducing the amount of water that enters the sewerage system. The Inflow and Infiltration Reduction Program will launch firstly with an investigation phase in the Mullumbimby town area due to the high risk of local flooding and overflow of the Mullumbimby sewerage system into the Brunswick River. Mullumbimby receives high rainfall and experiences significantly high levels of inflow and infiltration. This causes localised residential septic backup, places the Brunswick River at risk of pollutants from overflow and increases costs of electricity, treatment and maintenance at water pump stations. Contributing factors are outdated residential plumbing systems (pre-1980s) that connect directly to the sewerage system, defects in sideline connections from private properties to the mains, and low lying overflow relief gullies (ORGs) that are susceptible to flooding. As weather is becoming more extreme, the population and tourism to the town is increasing, pipe infrastructure was deteriorating on last inspection and new development has placed pressure on infrastructure such as roads and swales, it is timely to investigate the scope of the inflow and infiltration issue. Flow meters have been installed into the sewer network to provide accurate, localised data. Other planned investigation methods include CCTV pipe inspection, smoke testing and community surveying. The results of the investigation will help determine sustainable solutions and identify responsibility for future costs. Three pilot projects are planned for Mullumbimby to demonstrate and test the suitability and effectiveness of Water Sensitive

	Urban Design. The reduction of inflow and infiltration, reduction of water demand and use of Water Sensitive Urban Design to improve drainage in times of flooding will assist in providing a sustainable and sanitary sewerage system for the community and protect the health and biodiversity of the Brunswick River.
Governance	NA
Objectives	The community is informed about the processes involved in reducing inflow and infiltration into the sewerage system and is encouraged to: 2. Inspect their premises, update old plumbing and assist Council with any inspections; 3. Use water sensitive urban design to help Council reduce future risk; and 4. Use water efficient household appliances and fixtures to reduce water demand and waste.
Sensitivities, challenges and strategies	Considerations: • Council is often criticised for inadequate sewerage systems and local flooding. **Strategies:** Increase awareness of shared responsibility. Educate the community as to how and why these problems occur. Empower the community to take action by showing them what can be done through positive behavioural examples. • There may be an expectation that this project will fix all the sewer problems in Mullumbimby. **Strategy**: Highlight through the community survey, social media and other community publications that Council is in an investigation and testing phase. The gathering of information will assist in making the best decisions for a sustainable sewerage system for the future. It is an ongoing and evolving process to accommodate the changing and more extreme weather and growing population. • People do not trust Council to be able to find a solution to sewer problems. **Strategy:** Reinforce Council as the authority in water and sewer issues for the community, supported by industry experts who seek out sustainable solutions. Provide examples of successful projects and highlight the benefits. Reinforce the community shares in this responsibility and can take action through positive behavioural change. • Access issues (privacy issues) may be raised by stakeholders, individuals and groups. **Strategy**: Reassurance that any investigation is project related and solution focused and that areas requiring access will be limited to gully traps and inspection openings by authorised Council employees.

	• Heavy rain, slow drainage of floodwater and residential sewage backup has been a long-term issue in Mullumbimby and some residents may be at a stage of escalation. **Strategy**: Acknowledge the issue is unacceptable and change must occur. Investigation is first needed. Provide information on the benefits of Water Sensitive Urban Design. • Small number of people in Mullumbimby and Brunswick Heads are publicly and highly critical of Council over the management of the sewerage system. **Strategies**: Extend opportunity to select community members to act as an ambassador to explain the inflow and infiltration 'problem' and introduce terminology to the public in plain language through Council promotional materials. This allows them to share their ideas with Council while educating the public about the problem and work with Council to solve the problem. If successful this is an opportunity to create a potential (and influential) ambassador for the project. • Small number of community experts may be insistent on other solutions, not within the project scope, or be critical of Council's efforts, placing community engagement at risk. **Strategies**: Communicate with individuals in early stages of investigation phase, provide a project brief and document their feedback and comments. Establish a community spokesperson with the Mullumbimby Residents Association who can pass on more detailed information to interested members of the public or to those who do not have online access. Commitment to open communication and a layered communication campaign. Advise the individuals that the public will receive a simplified promotional campaign however more detailed information for experts and interested individuals will be accessible at all times on the website, via an online forum (Bang the Table), through the Mullumbimby Residents Association or by writing to Council. • Existing personal history with employees and ex-employees in the Water and Sewer section may attract criticism. **Strategy:** Remain professional at all times, communicate key messages at the simplified level and remain solutions focused. Minimise communication with individuals if necessary. Refer to the Mullumbimby Residents Association spokesperson for more detailed information. • Community members feel the Water Sensitive Urban Design will change the 'Heritage' look and feel of the town and increase population growth. **Strategies**: Compare the problems to the potential benefits of the Inflow and Infiltration programme and provide information on the benefits of Water Sensitive Urban Design. Reassure the community that building facades are not involved in the project and that any Water Sensitive Urban

	Design projects will aim to compliment the existing look and feel of the town as well as reduce inflow and infiltration. • Community members want to have control over the creative aspect of the streetscape with regards to Water Sensitive Urban Design. **Strategy**: Reassure the community there is opportunity for them to view the process and provide feedback on the three pilot projects as well as provide input through the community survey. Further opportunities may become available for creative collaboration, such as street-based rainwater and edible gardens.
Key messages	1. Council is undergoing an investigation and testing phase to consider sustainable solutions for water, inflow and infiltration reduction in Mullumbimby and the Byron Shire. 2. Ideas and input are sought from anyone with an interest or view on water, inflow and infiltration reduction in the Shire. 3. Council is committed to providing a sanitary sewerage system in the Byron Shire for the safety, health and wellbeing of our community and conservation of our natural environment. 4. An improved sewerage and stormwater network is needed to better accommodate the area's growing population and more extreme weather in the future. 5. This process will help us understand the scope of inflow and infiltration in the Mullumbimby area, assist with providing the most sustainable solutions and help us to better plan for future infrastructure. 6. A good sewerage network requires a combined approach from council and community. 7. We encourage water sensitive urban design as a sustainable mode of reducing inflow and infiltration as well as complimenting street aesthetics and potentially lowering the air temperature of public spaces.
Media spokesperson	Jason Stanley – Project Manager Inflow and Infiltration Phil Holloway – Director Infrastructure Services
Work contact	Jason Stanley – 6685 9349 Annie Lewis – 6626 7320 / 0419 609 189
Potential level of impact	**Level 1 –** local area but high impact
Our promise **IAP2 Public Participation**	**Inform –** We will keep you informed.

Spectrum		
Stakeholders	**Internal** • All staff • Executive Team • Customer Service • Councillors • Major Projects Group • Council Committees – Water & Sewer • Community Roundtable	**External** • Ratepayers • Residents • Mullumbimby Residents Association • Brunswick Heads Progress Association • Local media • Mullumbimby Chamber of Commerce • Brunswick Heads Chamber of Commerce • Local businesses • Local environmental groups such as Brunswick Valley Landcare, community gardens • Mullumbimby Public School • Plumbers • Nurseries • Arakwal
Evaluation	Success will be measured by: • General community understanding of and engagement in the project. • Development of positive, constructive relationships with Mullumbimby residents. • Reduction of inflow and infiltration into the sewerage system.	
Internal staff	Staff to be made aware of the project and its timeframes.	
Submitted to Director or Manager	Phil Holloway / Mark Arnold	
Reported to ET		
Reported to Comms Panel/Council	30 May 2019	

Task	Audience	Details	Who is doing it?	Cost	Date to start/finish
Notify Arakwal	Arakwal	Notify Arakwal Corporation of the project. To be advised via email and phone.	Katrina Curran, AWC		
Information Session	Residents and community	Drop-in information session held at Council Chambers.	Jason Stanley	Staff time	Tuesday 11 December 2018, 5-7pm
Briefing of Communications Panel (Crs Richardson, Coorey, Ndiaye, Martin)	Internal	The Communication Plan will be shared with Council's Communications Panel to ensure they are aware of the plan, and the methods being used to promote the plan to the community and to staff.	Jason Stanley Annie Lewis	Staff time	30 May 2019
Development of information for the community including survey, FAQs and flyers	External	Community survey and comprehensive FAQs and information for the community to be developed. Note: A graphic designer may be required.	Merran Davis Jason Stanley Katrina Curran, AWC	Staff time	June 2019
Attend meeting of Mullumbimby Residents Association	External	Attendance at a meeting of the Mullumbimby Residents Association to discuss the project, timeframes etc.	Jason Stanley	Staff time	June 2019
Letter and survey to Residents, Businesses and Stakeholders	External	Letter and survey to be delivered to all residents in the area requesting information on stormwater and wastewater flooding.	Jason Stanley Merran Davis Annie Lewis	Staff time	
Editorial content	External	Community and industry newsletters	Merran Davis	Staff time	ASAP

Website	All	Website to provide information, FAQs, contact details	Comms Team Merran Davis	Staff time	ASAP
Media releases as required	All	Media Release 1 • To alert people and businesses about the smoke testing, CCTV inspections and upcoming pilot projects in WSUD. Media Release 2 • Launch of WSUD pilot projects Media Release 3 • Results of WSUD pilot projects	COMMS Merran Davis	Staff time	June 2019 and tbc
Subscriber E-News	External	Promote media releases and project survey responses/database	COMMS Merran Davis	Staff time	
BSC Facebook posts	External	Promoting media releases and other messages as required.	COMMS	Staff time + $100 for boosted posts if required	

Display advertising (print) (if required – tbc after committee meeting)	External	Advertisements in local print media Stage 3 phase or later. Potential community call to action for pilot projects.	Mick Crosbie	Staff time Advertising Costs - $1500 Design - $150	2 x ¼ page ads
Staff update and promotion of project, monthly internal newsletter	Internal	Promotion and explanation of project to all staff through a monthly newsletter and all staff messages (when appropriate).	COMMS	Staff time	
Customer Service updates	Internal	Customer Service to be briefed.	Merran Davis Jason Stanley	Staff time	

AWC

Technical Memorandum

Summary for Water and Wastewater Advisory committee

To:	Jason Stanley
From:	Katrina Curran
Date:	03/06/2019
Pg/Attach.:	
Job ref:	1-18999

Project Update

Three locations where chosen within Mullumbimby have been chosen to investigate and monitor stormwater inflow and infiltration to the sewer network as part of the Mullumbimby Sewer Inflow and Infiltration Study. These sites were selected as case studies due to their location within the sewer network. They are reflective of the broader issue of stormwater intrusion to the sewer network throughout Mullumbimby.

Flow meters where installed within three manholes and continually monitored flows between the 1st of December 2018 and 1st of April 2019 to provide an understanding of how flows change in relation to daily usage, rainfall events and infiltration into the sewer network from high groundwater and cracks in the pipe network.

An analysis of the issues relating to the sewer network and surface stormwater flows was also conducted to further understand and characterise the inflow and infiltration component. This included survey and site investigations within the three investigation areas Zone 1 south of Tyagarah Street, Zone 2 north of Burringbar Street adjacent to the river and Zone 3 within the centre of the town.

Water | Ecology | Management

8 George St
Bangalow NSW 2479

p. (02) 6687 1550
e. info@awconsult.com.au
w. awconsult.com.au

Australian Wetlands Consulting Pty Ltd
ABN 81 140 533 919

AWC

Stormwater management within Mullumbimby

Presently little to no management of stormwater in what would be considered a water sensitive approach occurs in Mullumbimby. This means that actions to include WSUD are likely to have significant benefit to both the amount of the local community and the environment. The adoption of WSUD within Mullumbimby will enhance the local environment while taking pressure off the town's sewage network. A number of issues and opportunities in the development of a water sensitive approach in Mullumbimby have been identified and include:

- Existing stormwater infrastructure is old and often undersized (Ardill Payne, 2018)
- Aging stormwater infrastructure with low grade in results in poor conveyance and localized flooding
- Localized flooding leads to sewer infiltration particularly in rear lanes
- Inspection pits located adjacent to stormwater swales are access points for direct inflow to sewer
- Lack of conveyance also increases infiltration due to long periods where there is standing water at the surface
- It is likely that there a large number of illegal connections of stormwater to sewer, particularly in older parts of town (possibly 20 – 50% of properties)
- Roof water drains directly to swales and roadways and could be intercepted reducing peak discharge of stormwater and inflow to the sewer system

There are numerous locations where stormwater within laneways cannot physically reach the dowsnstream stormwater network, meaning flooding occurs in even small storm events. Installation of WSUD devices can have a significant positive impact on reducing peak storm flows whilst reducing infiltration to sewer.

The key objectives developed for the development of this WSUD concept for the three investigation areas in Mullumbimby are as follows:

- Identify potentially suitable locations where retrofit of stormwater infrastructure can be achieved
- Determine flow volumes that can be captured to reduce localised flooding and inflow to the sewer network
- Stormwater management should integrate with the existing heritage streetscapes
- Stormwater management should maximise opportunities for harvest and reuse to reduce potable demand and inflow to the sewer network
- Stormwater treatment devices should use locally suitable native plant species to mimic and support local biodiversity
- Stormwater treatment should be integrated to allow both a reduction in localised flooding and removal of pollutants to protect and enhance downstream environments

The following images (Plates 1-5) highlight some of the key issues for stormwater management and inflow reduction in Mullumbimby

Plate 1 and 2 Poor stormwater conveyance in laneways

Plate 3 Inspection and observation pit located adjacent to flooded stormwater swale

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Plate 4 Localised flooding opposite Council chambers

Plate 5 Poor conveyance and lack of maintenance in surface stormwater infrastructure

AWC

How much water can be captured?

Installation of WSUD devices can substantially reduce peak storm flows, with numerous case studies demonstrating that devices such as raingardens reduce stormwater discharges from urban environments. Rainwater tanks can also be effective for capturing roof run off if they are connected to a frequent use (e.g. irrigation) or used to delay discharge to a drain.

Potential volumes which can be intercepted have been calculated using the 3-month ARI storm for Mullumbimby which corresponds to approximately a 40mm rainfall event. It should be recognised that storage and detention can be increased or reduced depending on available space and priority sub catchments where pressure on the sewer system is greatest. By capturing rainfall at the surface we prevent it from entering the sewer network and reduce the peak flows in the system.

Sewer flow monitoring

Monitoring of sewer flows has been ongong since December 2018 and clearly demonstrates the increase in flow rates in the Mullumbimby sewer network when rainfall occurs. Figure 1 shows rainfall (mm) and flow (L/sec) for the rain guage and flow metres installed at the three locations within Mullumbimby. Zone 1 and Zone 2 are located at the beginning of the sewer network and so receive less run-off than Zone 3 which is located downstream of Burringbar Street.

It is useful look at to the understand how flows increase during a rainfall event at each location to compare dry weather flows with flows during rainfall events. Figure 2 demonstrates the rapid increase in sewer flow rates in response to rainfall, two four-day periods 03/12/2018 to 07/12/2018 and 20/12/2018 to 24/12/2018 for Zone 1.

The rapid response shown indicates that inflow to the sewer network is an issue with flows increasing from a maximum of 0.5L/sec during dry weather and then increasing to 1.5L/sec during rainfall.
The following table summarizes the key characteristics of Zone1.

Table 1 Zone 1 surface area dry and wet weather flow rates, no. of lots and target surface stormwater storage to reduce inflow

Zone 1 surface area (m^2)	17873
Dry weather flow rate (L/sec)	0.5
Wet weather flow rate (L/sec)	1.5
No of lots upstream of flow monitoring point	25
Target storage volume Q3 event (m^3)	102

A similar pattern is demonstrated in Zone 2 with flows increasing from 0.5L/sec to 2L/sec during rainfall events.

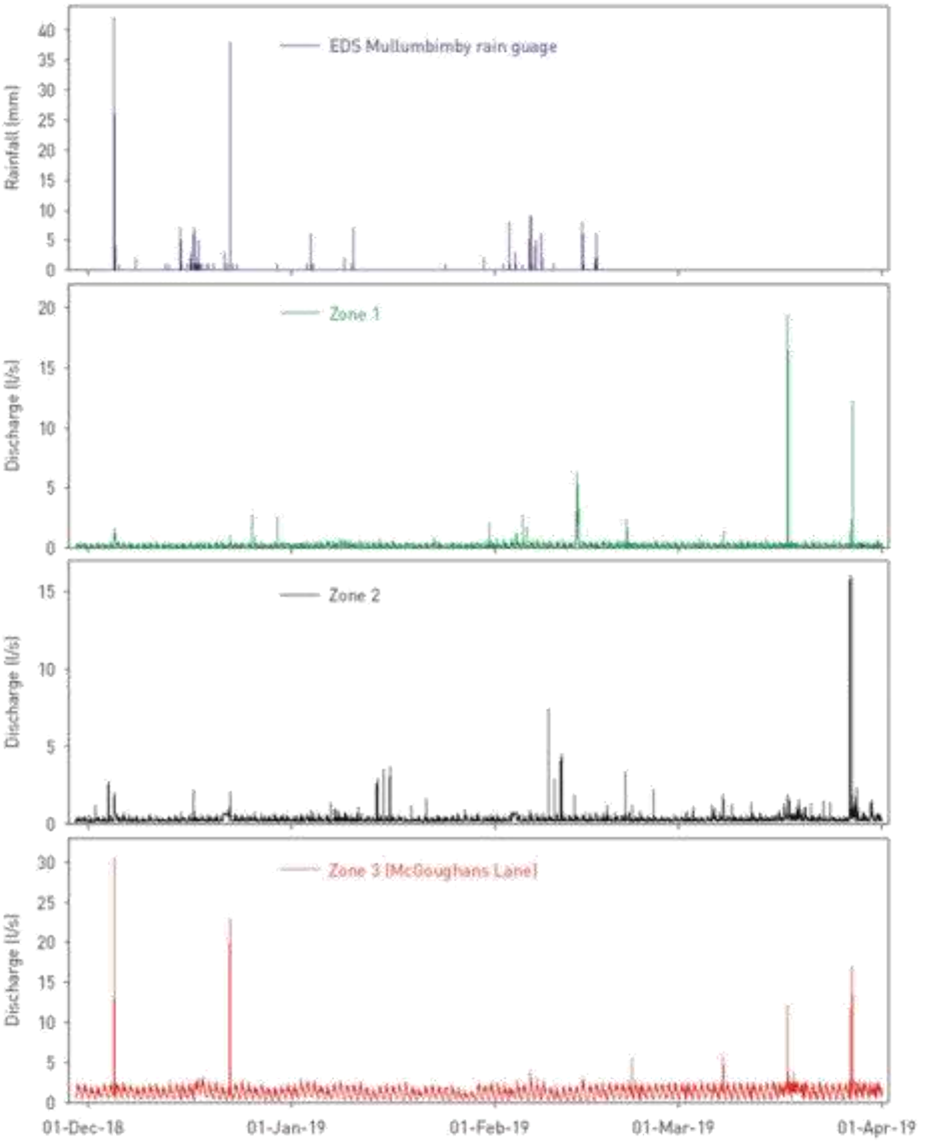


Figure 1 Rainfall and flow data for the Mullumbimby Sewer Inflow and Infiltration monitoring study between December 2018 and April 2019. Note rainfall data requires inclusion for the period March to April 2019

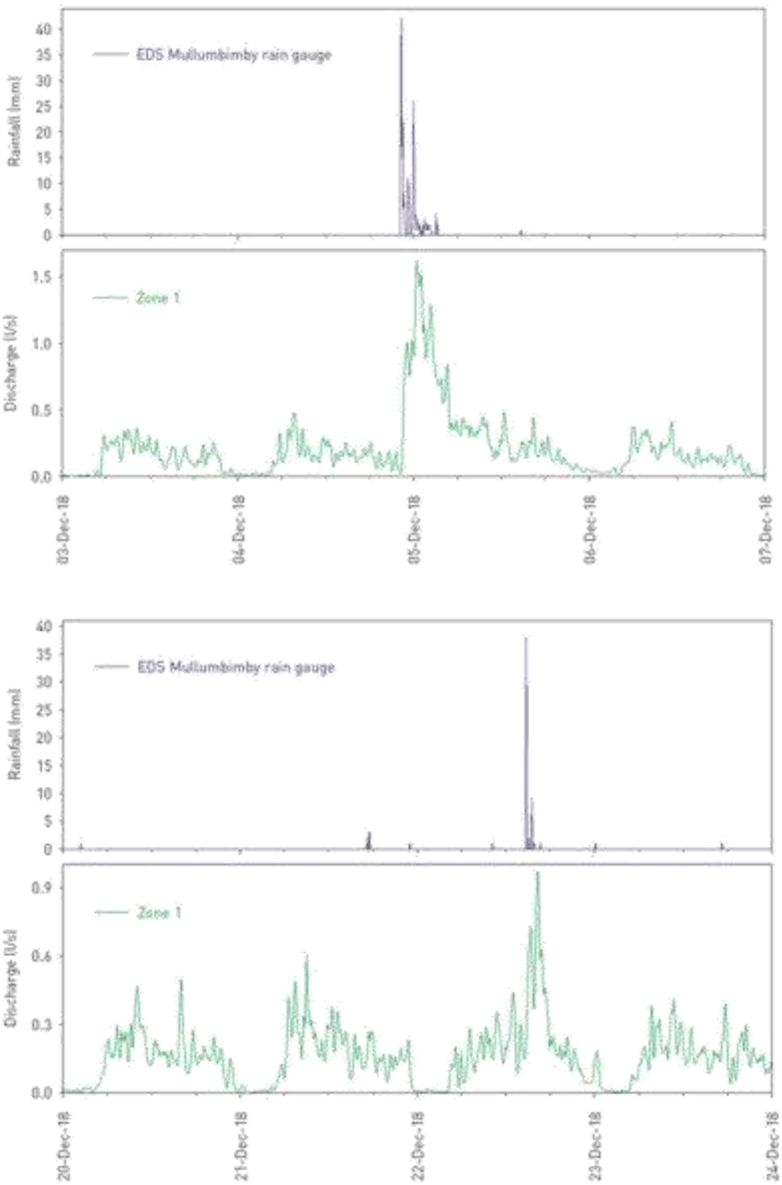


Figure 2 Zone 1 rainfall and sewer flow rates for two rainfall events in December 2018

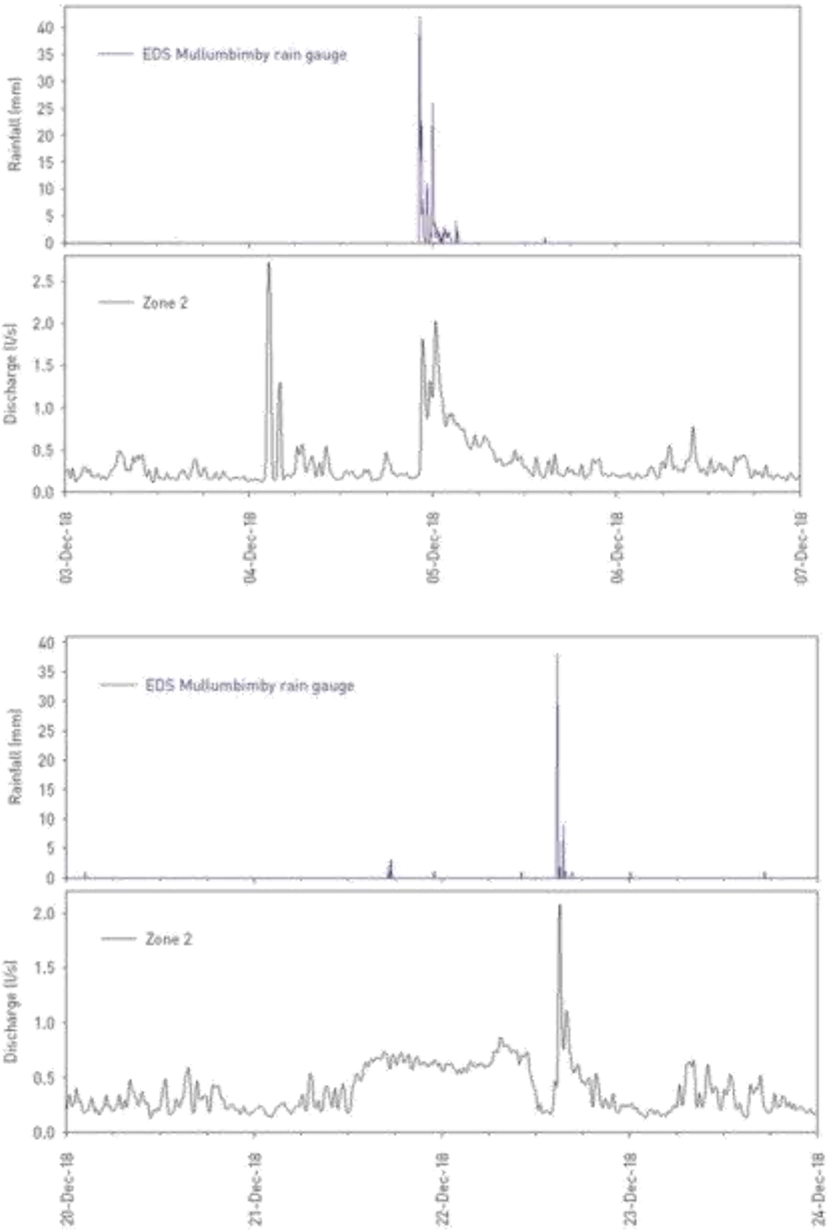


Figure 3 Zone 2 rainfall and sewer flow rates for two rainfall events in December 2018

AWC

Periodically there are elevated flows within Zone 2 in the absence of rainfall as shown in the period 04 to 07/02/2019 above (Figure 2). This is possibly linked to commercial uses within the catchment including the Byron Bay community college and mechanics.

Table 2 Zone 2 surface area dry and wet weather flow rates, no of lots and target surface stormwater storage to reduce inflow

Zone 2 surface area (m^2)	24481
Dry weather flow rate (L/sec)	0.5
Wet weather flow rate (L/sec)	2.5
No of lots upstream of flow monitoring point	22
Target storage volume Q3 event (m^3)	81

The effect of inflow to the sewer network in Zone 3 is much greater than Zones 1 and 2 with flow rates increasing from a base of up to 2.5L/sec to 25 L/sec during rainfall events. Flows are likely to be increasing so dramatically in the central part of town due to the large number of properties connected to the sewer network plus a higher portion of impervious surfaces including roads and roofs. The dramatic increase in flows probably also reflects a number of direct connections of stormwater to sewer.

Table 3 Zone 3 surface area dry and wet weather flow rates, no of lots and target surface stormwater storage to reduce inflow

Zone 3 surface area (m^2)	137401
Dry weather flow rate (L/sec)	2.5
Wet weather flow rate (L/sec)	25
No of lots upstream of flow monitoring point	134 (mixed use)
Target storage volume Q3 event (m^3)	182

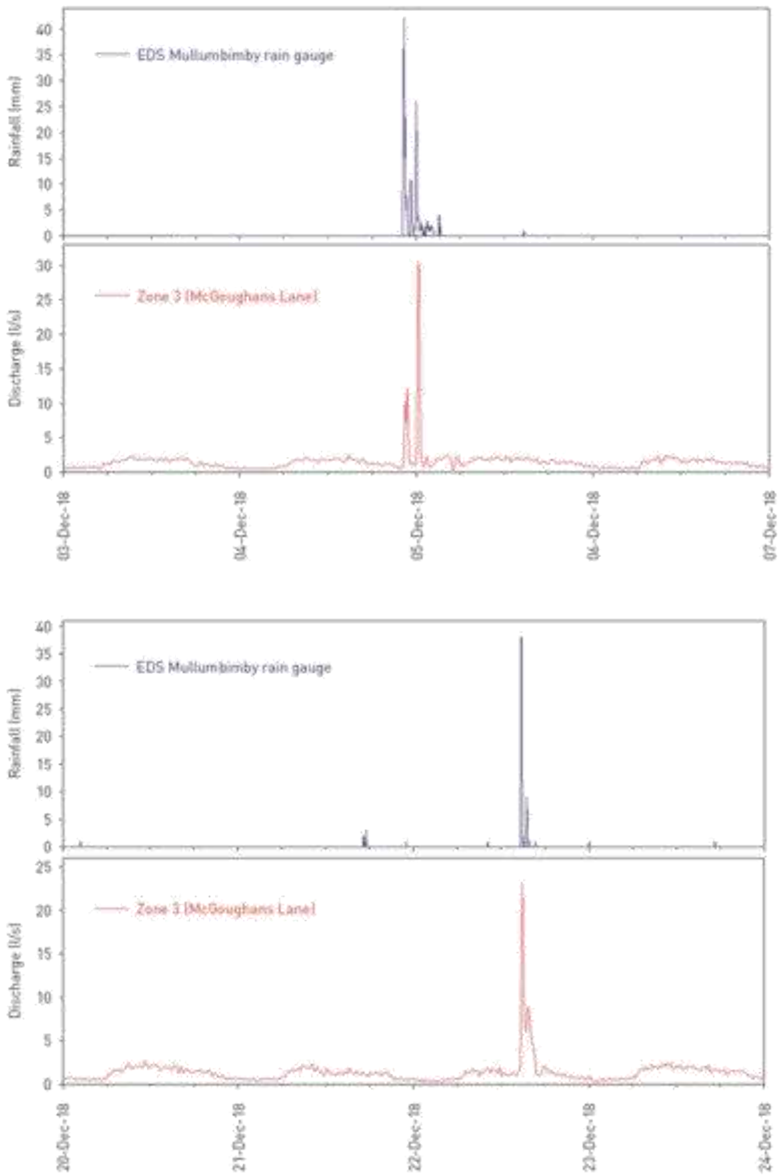


Figure 4 Zone 3 rainfall and sewer flow rates for two rainfall events in December 2018

Mulumbimby Sewer Inflow and Infiltration WSUD Site Analysis and Concept Development

AWC has completed a detailed analysis of the opportunity to utilise WSUD urban design within Mullumbimby to reduce inflow and infiltration. This analysis confirms a large number of opportunities to reduce inflow and inftilration of stormwater to sewer through the adoption of water sensitive urban desin practices. Further detail is provided in the attached options analysis and plans and summarised below.

Direct inflow can be reduced through harvesting roof runoff and preventing it from entering the stormwater system. Roof run-off can be harvested through rainwater tanks and raingardens (Plates 6, 7 and 8)

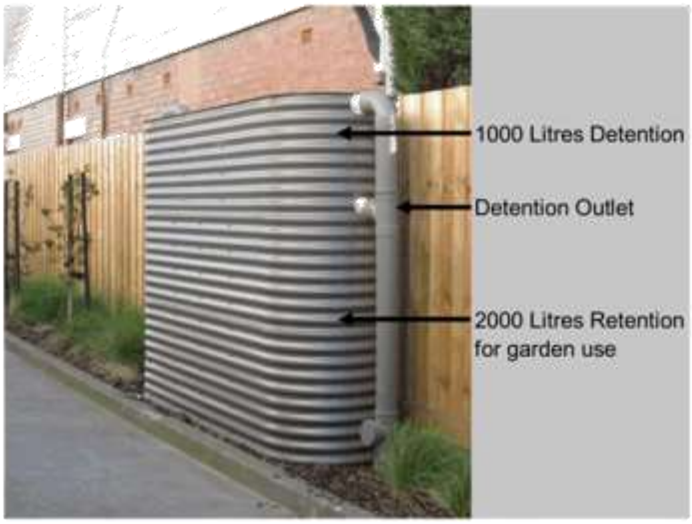


Plate 6 Rainwater tanks with stormwater detention function. 2

Plate 7 Raised planter rain garden

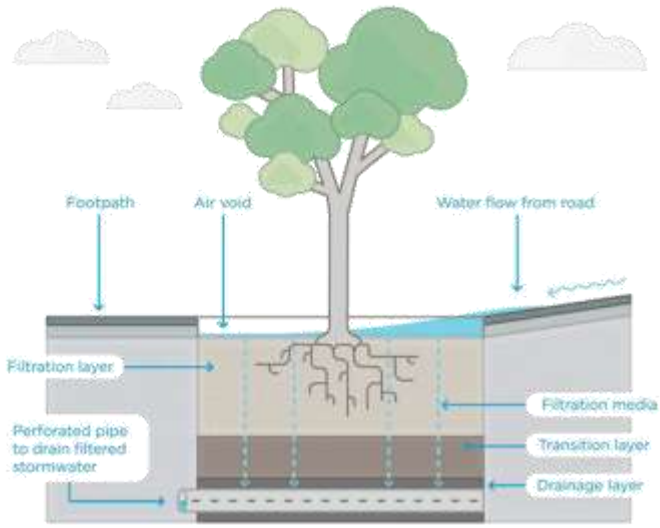


Plate 8 Street tree rain garden

Existing swale infrastructure can also be redesigned to better convey stormwater flows and reduce inflow and infiltration of stormwater to sewer. This assessment and design work confirm that the Q3 month ARI storm flow volume can be captured within a suite of water sensitive urban design measures (see a summary in Table 4). By capturing the 3-month ARI storm flow volume peak discharges within the stormwater network impacts to the sewer network can be significantly reduced.

These measures also provide secondary benefits including:

- Reduced demand for potable water
- Creation of a greener and more sustainable town
- Provision of shade and greenery throughout the town

The next stage of the project will develop a cost estimate for the strategy to then compare these costs with other options for reducing inflow and infiltration of stormwater to sewer.

Table 4- Summary of WSUD concept development showing proposed stormwater management devices and storage capture volumes

Stormwater device	Zone 1 storage (m3)	Zone 2 storage (m3)	Zone 3 storage (m3)
Street based raingarden	45.6	13.2	144.4
Raised planter raingarden	5.5	8.3	91.5
Bioretention swale	0	27.8	0
Regraded swale	23.6	32.6	0
Street tree raingarden	3.2		2.4
Rainwater tanks	23.9	12.7	22.9
Target volume	102	81	226
Total in devices	107.5	94.5	278.2

Conclusion

This investigation has confirmed that stormwater inflow to sewer is contributing substantially to pumping volumes to Valances Road STP. Flow monitoring shows that infiltration to sewer occurs almost immediately after a rainfall event, meaning that local management of stormwater through WSUD can provide significant benefit.

This investigation has quantified volumes of stormwater which could be intercepted based on the Q3-month ARI storm event and identified locations where works could be undertaken. Our recommendation is that a cost benefit analysis and investigation of additional catchments be completed.

Report No. 4.2 **Byron Bay Integrated Management Reserve Update**
Directorate: Infrastructure Services
Report Author: Bryan Green, Water Sewer Systems Environment Officer
File No: I2019/1588

Summary:

This report is in response to questions raised by the Waste and Water Sewage Advisory Committee, and subsequent recommendation that a report be submitted to Council detailing Council's fulfilment (or not) of the Condition 9, of its DA approval (in 2002) for the Byron Bay STP.

Recommendation:

1. **That Council note the report**

Attachments:

1 Sandmine Track - Byron Wetlands_Mining PATH 1..pdf, E2019/73091 , page 49⇩
2 Sandmine Track- Byron Wetlands_Mines Dept Belongil.pdf, E2019/73093 , page 50⇩
3 Updated Byron Bay Wetland Cells - Phosphorus Study, E2019/73674 , page 51⇩
4 Report by AWC to assess Acid Sulfate Soil potential in the 24 Ha Byron Bay Wetlands (1-191162_01a_Byron Bay Wetlands_Pyrite_Testing_20191003.pdf), E2019/74709 , page 75⇩

REPORT

The following questions were required to be answered from Council Resolution 19-466.

Q1. That Council receive further information from Committee members before undertaking further investigation related to the Sandmining Path near Byron Bay STP

Staff Response: At the 29 August 2019 WWSAC meeting the Committee requested Col Draper provide evidence of the location of the Sandmine Track – **Attachments (E2019/73091 and E2019/73093)**.

A further suggestion was to meet on site to identify the location of the Sandmine Track.

Utilities staff welcomes a site visit to assist with identifying the location of the Sandmine Track but more importantly that Council can investigate a perceived and / or possible effect it may be having on the Catchment.

Q2. That Council monitor phosphorus levels in the soil of the Wetlands area in order to Monitor sequestration and the approach towards sorption capacity of phosphorus over future years

Staff Response: Please see **Attachment 1 (E2019/73079).**

Q3. That up to date data collected on acid sulfate soil performance with the 24 ha wetlands be circulated to committee members.

Staff Response: Due to time constraints a full detailed report of the acid sulfate performance (Pyrite) of the 24 ha was not available to be attached to this agenda report.

The report will be provided prior the meeting.

Q4. That Council receive a report in 2019 via its WWS Committee on fulfilment or not of Condition 9 of its DA approval (in 2002) for the Byron Bay STP.

Staff Response: In 2002 the Byron Sewage Augmentation Scheme was initiated. This scheme comprised of the upgrading of West Byron Sewage Treatment Plant (STP), decommissioning of South Byron STP, construction of a sewerage transfer pipeline between South Byron STP and West Byron STP, and upgrading of associated pumping stations.

As part of this scheme, a “Clause 91 Report” was completed by Connell Wagner Pty Ltd on behalf of Byron Shire Council. This report highlighted various conditions of approval to the scheme. Council have requested information regarding the fulfilment (or not) of Condition 9 from the report. Condition 9 is detailed below.

9. *Acceptance of any additional load at West Byron STP will not be accepted until:*

   (i) The transfer of 100% of the sewage flows from South Byron catchment;

   (ii) West Byron STP satisfactorily meeting all applicable performance requirements as specified in the plant’s Environment Protection Licence and in this approval;

(iii) Availability of sufficient reuse capacity to accommodate 100% of the volume of treated effluent generated by the additional load; and

(iv) Availability of treatment capacity as defined in Approval Condition 6 above.

A response to each item is detailed below:

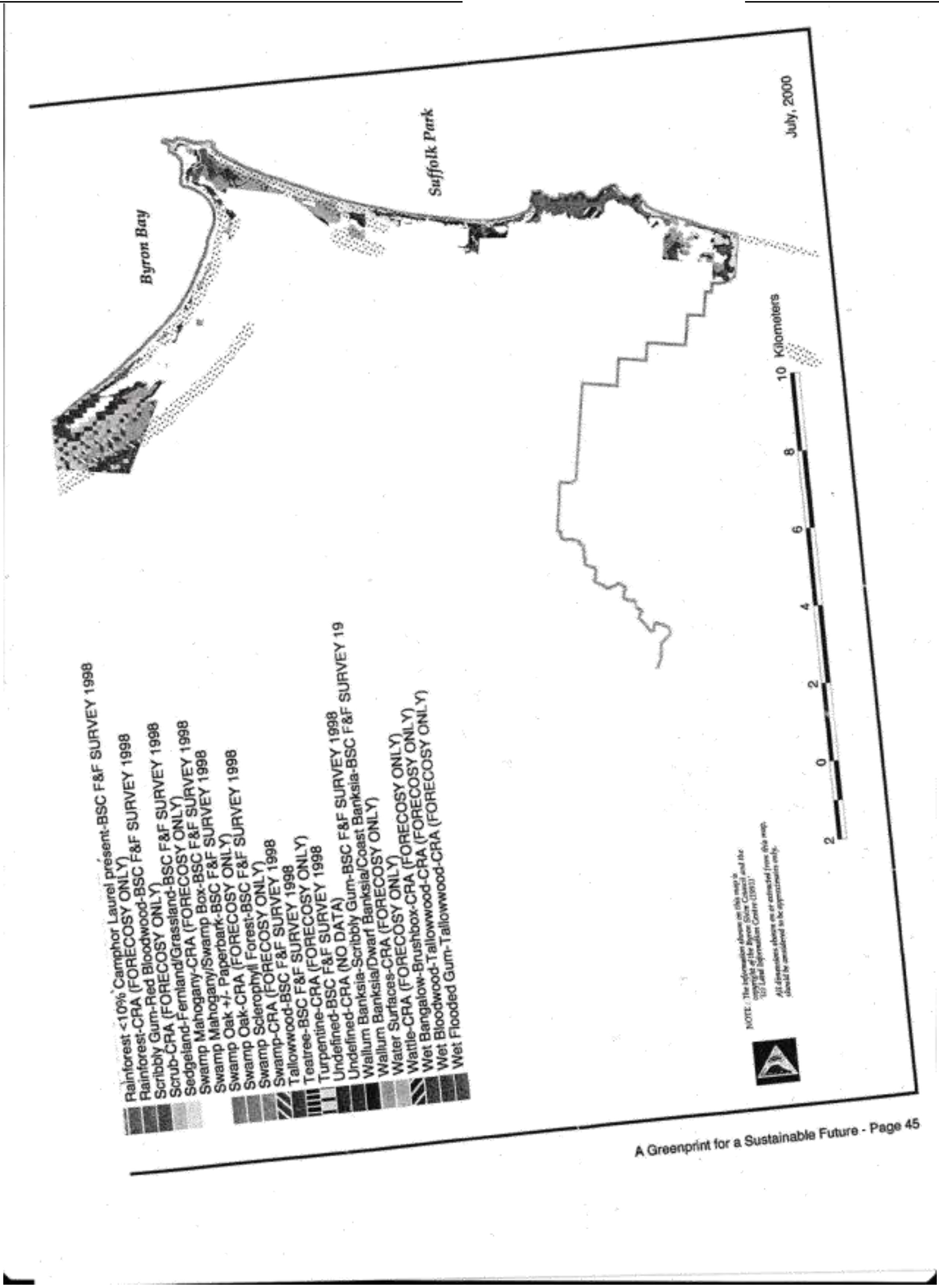
(i) The sewage from the South Byron catchment was transferred to the West Byron STP in 2005.

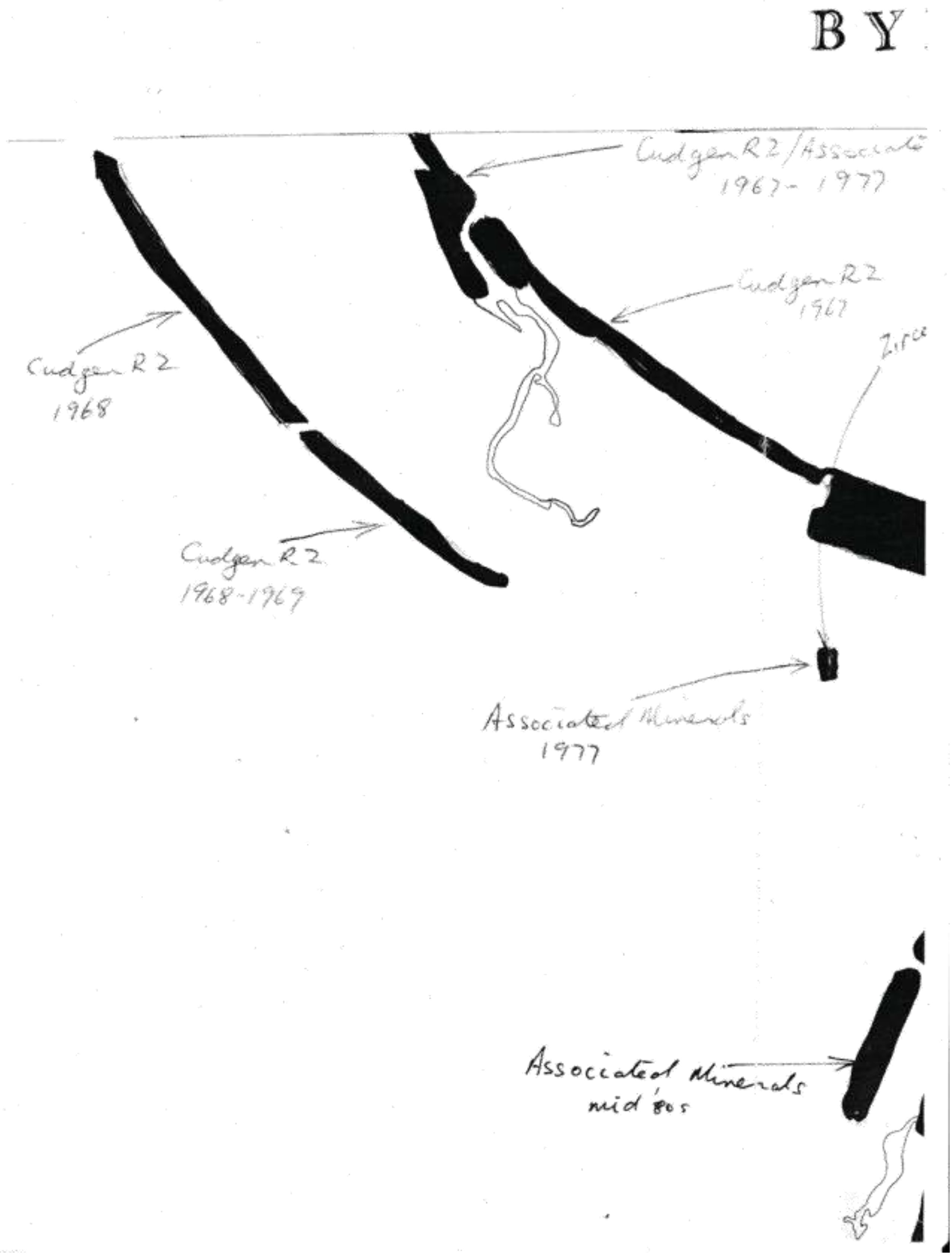
(ii) Routine testing, as required by the Environmental Protection Licence, confirms that the plant meets all applicable performance requirements. This is detailed in the annual report completed each year on the plant's performance.

(iii) Since the approval of the scheme, lifting of the Sewerage Moratorium in 2006, and the transfer of all South Byron flows into the West Byron catchment, there has been an additional load of approximately 1.0Ml/day at the Byron Bay STP. At the time of approval, West Byron and South Byron STP's were each treating 2.0ML/day (4.0ML/day in total) on an average dry weather flow (ADWF). The current loading (Sept 2018-Sept 2019) on the Byron Bay STP is 4.8ML/day. The actual additional loading from development consents (which is the definition of additional loading) approved since the transfer of the South Byron flows to West Byron. Additional flow based on Development Consent was not permitted until the moratorium on development was lifted in April 2006 as per Council Resolution.

In the first 9 months of 2019, an average daily reuse of 1.1ML was supplied to customers (a total of 309.6ML supplied from 01 January 2019 to 30 September 2019). This is in excess of the 100% of additional loading requirement set out in Condition 9.

(iv) It is confirmed, that at the time of upgrade, the treatment capacity was increased to the 6.95ML/day as required by Condition 6 of the Clause 91 Report.


Byron Bay
Suffolk Park
July, 2000
Kilometers
2 0 2 4 6 8 10
Rainforest <10% Camphor Laurel present-BSC F&F SURVEY 1998
Rainforest-CRA (FORECOSY ONLY)
Scribbly Gum-Red Bloodwood-BSC F&F SURVEY 1998
Scrub-CRA (FORECOSY ONLY)
Sedgeland-Fernland/Grassland-BSC F&F SURVEY 1998
Sedgeland-Fernland-CRA (FORECOSY ONLY)
Swamp Mahogany/Swamp Box-BSC F&F SURVEY 1998
Swamp Oak +/- Paperbark-BSC F&F SURVEY 1998
Swamp Oak-CRA (FORECOSY ONLY)
Swamp Sclerophyll Forest-BSC F&F SURVEY 1998
Swamp-CRA (FORECOSY ONLY)
Tallowwood-BSC F&F SURVEY 1998
Teatree-BSC F&F SURVEY 1998
Turpentine-CRA (FORECOSY ONLY)
Undefined-BSC F&F SURVEY 1998
Undefined-CRA (NO DATA)
Wallum Banksia-Scribbly Gum-BSC F&F SURVEY 19
Wallum Banksia/Coast Banksia-BSC F&F SURVEY 1998
Wallum Banksia/Dwarf Banksia-CRA (FORECOSY ONLY)
Wallum Banksia-CRA (FORECOSY ONLY)
Water Surfaces-CRA (FORECOSY ONLY)
Wattle-CRA (FORECOSY ONLY)
Wet Bangalow-Brushbox-CRA (FORECOSY ONLY)
Wet Bloodwood-Tallowwood-CRA (FORECOSY ONLY)
Wet Flooded Gum-Tallowwood-CRA (FORECOSY ONLY)
A Greenprint for a Sustainable Future - Page 45


BY
Cudgen R2/Associated
1967-1977
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1967
Zircon
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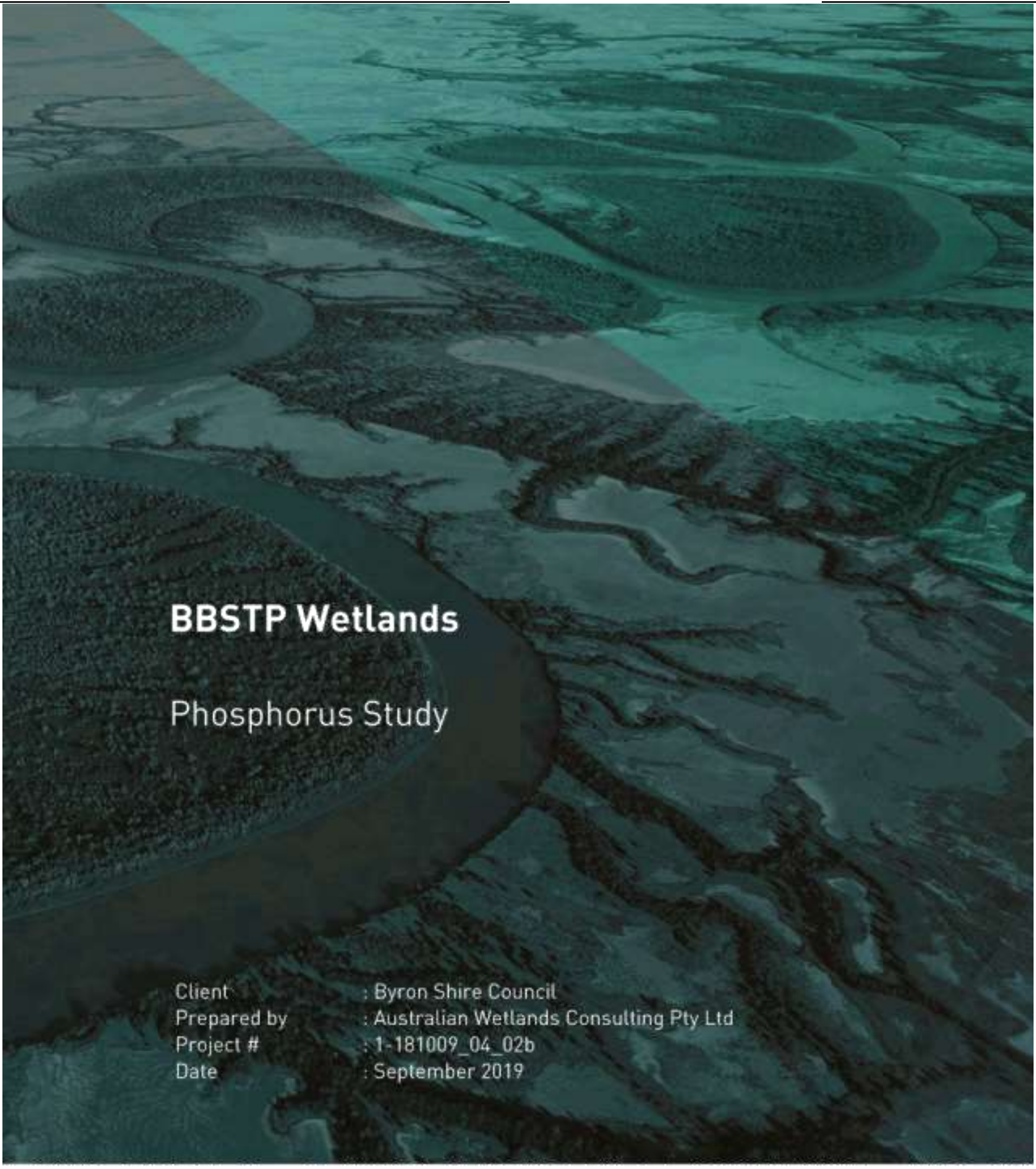
1968
Cudgen R2
1968-1969
Associated Minerals
1977
Associated Minerals
mid '80s



BBSTP Wetlands

Phosphorus Study

Client : Byron Shire Council
Prepared by : Australian Wetlands Consulting Pty Ltd
Project # : 1-181009_04_02b
Date : September 2019

Leading environmental solutions...

AWC

BBSTP Wetlands

Phosphorus Study

Project control

Project name: **BBSTP Wetlands**
Phosphorus Study

Job number: 1-181009_04_02b
Client: Byron Shire Council
Contact: Claudio Germany
Bryan Green

Prepared by: Australian Wetlands Consulting Pty Ltd

8 George Street
Bangalow, NSW, 2479

P | (02) 6687 1550
E | admin@awconsult.com.au

Date:	Revision:	Prepared by:	Reviewed by:	Distributed to:
10/09/2019	A	Mitchell Call Jesse Munro	Jesse Munro	Bryan Green
02/10/2019	B	Mitchell Call Jesse Munro	Jesse Munro	Bryan Green

Executive Summary

This study achieved its primary objective, revealing that the mineral soils in the Free Water Surface (FWS) wetlands still have considerable Phosphorus (P) sorption capacity, however, there is considerable variability between the four treatment cells studied.

Cell E has the lowest remaining P sorption capacity (304 kg P) likely related to the sandy soils. Cell D and Cell I had similar P sorption capacities (~1000 kg P) whilst Cell J has the highest remaining P sorption capacity (2207 kg P). The high estimate for Cell J may be related to the high vegetative cover, suggesting that there is little vertical movement of surface water. That is, instead of the water infiltrating the sediments and percolating downward, the surface water predominantly flows laterally across the surface of the soils.

The preliminary assessment of the two other P removal pathways, the accretive sediment layer and the vegetative biomass, suggest that both pathways are likely significant in terms of their P removal capability.

It is recommended that a long-term monitoring program designed to track and monitor changes in the P removal pathways over time (on the time-scale of years) be implemented. Such a study should aim to understand and identify any changes or issues which may diminish the performance of the P removal pathways and/or cause a release of P. Intermittent (3-5 years) sampling of soils to estimate the P sorption capacity as well as an assessment of vegetation biomass and accretive sediments is recommended.

Table of Contents

1 Introduction and Background

Phosphorus (P) is a nutrient required for plant and algal growth but is frequently a factor limiting their productivity. In aquatic ecosystems, the introduction of trace amounts of P into receiving waters can have profound effects on the structure of the ecosystem, potentially resulting in algal blooms and eutrophication.

Effluent from Sewage Treatment Plants (STP) is generally high in P and point source of pollution to receiving waters. Free Water Surface (FWS) wetlands are engineered systems built to provide advanced treatment of STP effluent and are capable of removing a portion of the P from the treated STP effluent thereby reducing the P load to receiving waters (Kadlec, 1995, Chen 2011) A typically constructed FWS wetland is a sequence of shallow treatment cells containing areas of open water, emergent plants, and/or floating vegetation. Effluent is discharged above ground at one end of a cell with water flow directed longitudinally to an outlet structure at the other end. As the effluent flows through the treatment cell, P is transformed and exchanged by the large variety of biotic and abiotic processes presented in Figure 1-1. The constructed FWS wetlands provide the appropriate conditions for the net long-term build-up of P with the three main P removal pathways in FWS wetlands being:

1. Sorption of phosphate (PO_4) to soil ("Sorbed P" in Figure 1-1). Sorption occurs when phosphate rapidly transfers from the soil porewater onto the solid soil particles. When the soil substrate has sorption capacity, sorption occurs until the entire soil of the wetland is loaded to the solid phase concentration corresponding to the soil pore-water concentration. Thus, this removal pathway has a finite capacity and can become saturated under long-term phosphorus loading. The time period to saturation depends on the soil chemical characteristics and the influent P loading rate which can vary from a few years to decades (Kadlec and Wallace 2009). Once saturated, desorption of P can occur and the soils may become a source of P to the water rather than a sink (Jamieson et al 2001, Penn et al. 2017). The sorption process occurs in the mineral soil component of the wetland soils (the "root zone" and "subsoil" stratums in Figure 1-1).
2. Increase in vegetative biomass. Macrophyte vegetation in treatment wetlands contributes to the removal of P through the uptake of nutrients from the influent stream. This storage compartment expands rapidly during the initial years of vegetation growth. However, this removal pathway eventually reaches equilibrium where the annual net uptake by existing and new biomass is approximate to the P that is returned to the water column by decaying biomass. As such this removal pathway is also saturable and finite. The same applies to the microbial and algal components of the wetland ecosystem (Kadlec and Wallace 2009).
3. Sediment accretion. New soil/peat is formed as a result of the settling of plant detrital residuals, undecomposable fractions of dead microflora and macrofauna (micro-detrital residuals), and sedimentation of inflowing particulates. This is considered a sustainable removal pathway and provides a net long-term storage of P (Kadlec and Wallace 2009). The accretion of this soil/peat layer occurs on top of the mineral soil component and is denoted as "Litter" in Figure 1-1.

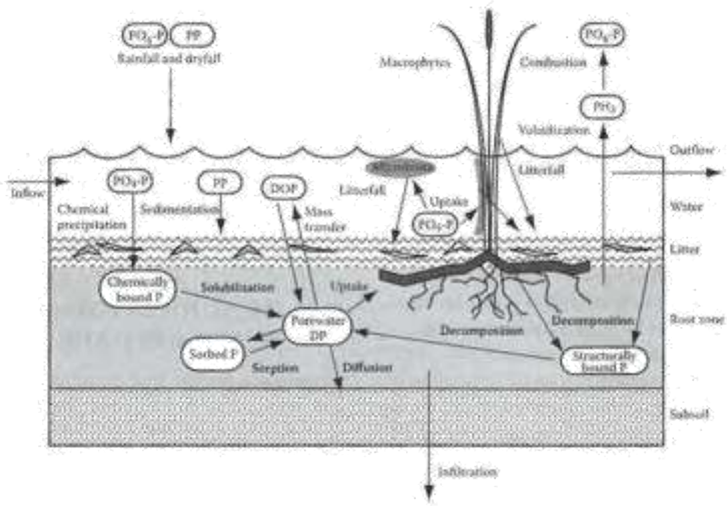


Figure 1-1 Conceptual diagram of phosphorus cycling in a FWS wetland (Source: Kadlec & Wallace, 2009)

The Byron Bay Sewage Treatment Plant (BBSTP) utilises FWS treatment wetlands as part of its integrated wastewater management strategy. Effluent that is not reused via the urban reclaimed water scheme is directed through the FWS wetlands to provide additional effluent polishing prior to release to the Belongil Estuary via the Union Drain.

The BBSTP has consistently achieved the targets set by the EPA with regards to the concentrations of P discharged from the site. Based on the BSC's monitoring data from the 10th May 2017 to the 27th March 2019, the average concentration of Total Phosphorus (TP) measured fortnightly at the inlet to the treatment wetlands (EPA1) was 0.11 mg/L. For the same period, the average concentration of TP measured fortnightly at the outlet of the treatment wetlands (EPA4) was 0.07 mg/L. This reduction in concentration suggests that there is active removal of P occurring. However, based on the age of the treatment wetlands (~ 15 years since the last upgrade), the P sorption capacity of the wetlands soils (i.e. the first removal pathway) may have potentially reached their equilibrium. As such, the primary aim of this study was to determine the P sorption capacity of the FWS wetland soils at the BBSTP. Preliminary assessments of the vegetative biomass (i.e. the second removal pathway) and sediment accretion (i.e. the third removal pathway) at the FWS wetlands were also conducted.

2 Methods

2.1 Study Site

The BBSTP FWS wetland contains seven polishing cells (Figure 2-1). As part of this study, four polishing cells, Cell D, Cell E, Cell I and Cell J, were assessed for their P sorption capacity, vegetative cover, and depth of sediment accretion.

Cells D, E and I were sampled on the 26th July, 2019 and Cell J was sampled on the 2nd August, 2019.

Specific characteristics of each Cell, as described in BSC (2006), are as follows:

- Cell D was completed and planted out in December 2005. Topsoil is of variable composition due to 'fill' being obtained from variable (free) sources. Problems with compaction in the eastern end resulted in this area remaining unplanted at construction.
- Cell E was completed and planted out in December 2004. The topsoil is composed of a sand and peat mixture.
- Cell I is a consolidation of the paddock that had previously received effluent discharges and may have accumulated nutrients in the soils. The cell also has an irregular substrate that leads to preferential flow paths rather than even flows through the cell.
- Cell J was planted out in April 2004. Topsoil was manufactured and is composed of a sand, clay and organic mix. The cell is 300mm deeper at the outfall than at the inflow.

Briefly, the flow of water through the BBSTP FWS wetland is as follows: effluent from the STP is discharged gently and uniformly via bubblers located at the western ends of Cell D, E, F, and G. Water exits Cells D, E, F and G at the eastern end of the cells into drains and/or vegetated swales that direct the water to bubblers that discharge into the northern end of Cells I and J. Water exits Cells I and J at the southern end of the cells into drains that exit the site and discharge to Union Drain. Cell H does not form part of the treatment train but is connected to the system for environmental flows.

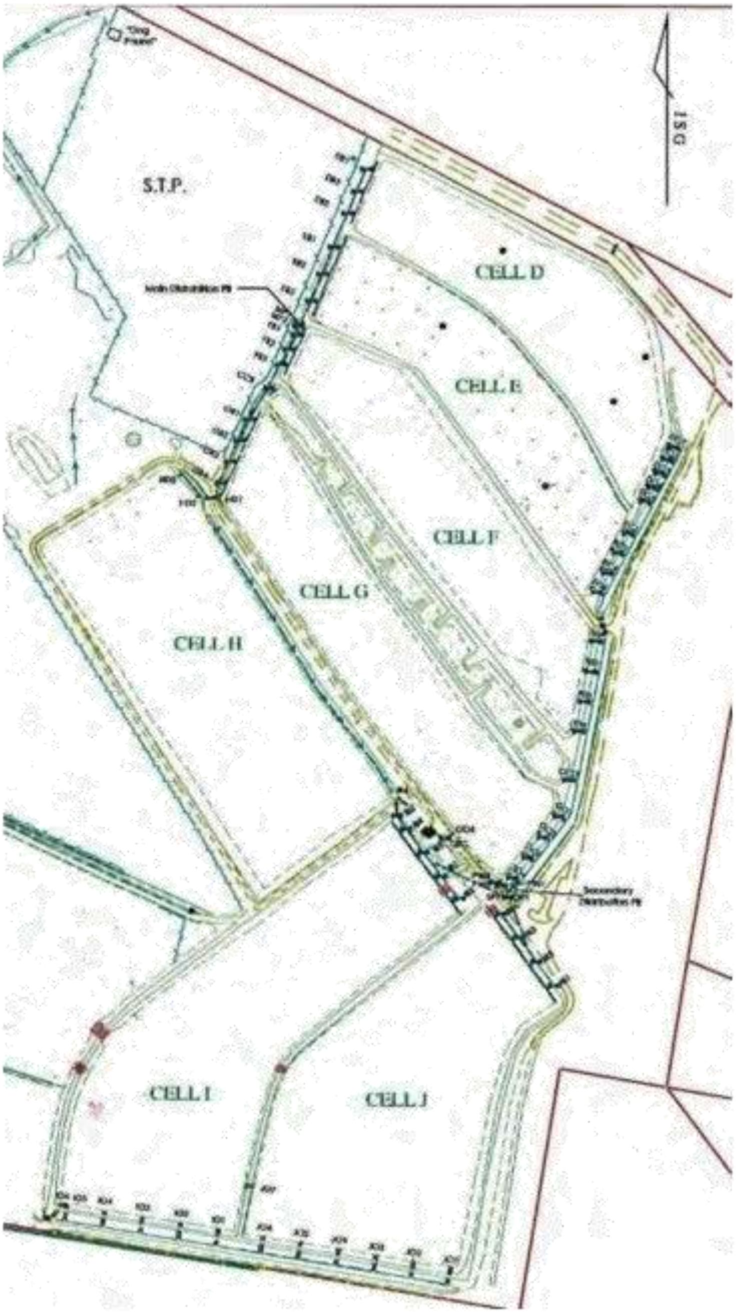


Figure 2-1 BBSTP FSW wetland treatment cells

2.2 Phosphorus sorption capacity of wetland soils

Soil samples were collected along three transverse transects in each wetland cell, with three sampling points along each transect as shown in Figure 3-1 and Figure 3-2. Using a hand auger, a soil core was extracted at each sampling point from which a sample of the mineral soil component was collected.

Mineral soil samples were immediately stored on ice until delivery to Environmental Analysis Laboratory (EAL) for analysis. EAL combined the three samples collected along each transect from which the remaining P sorption capacity was determined.

2.3 Vegetation assessment

A brief assessment of wetland vegetation was undertaken as part of this P sorption study. A more detailed vegetation assessment including weed and native plant cover, macrophyte assemblages and has been commissioned as part of a separate study and will not be detailed in this report. The main concern here is the percentage cover of primarily emergent macrophytes. The vegetation coverage was determined using GIS software based on the most recent NearMap aerial photography and ground-truthed.

2.4 Sediment accretion assessment

The depth of the accreted sediment layer was measured, along with water depth, at each sampling point. A sample of the accreted sediment layer, which sits atop of the mineral soil component, was collected at each sampling point and its depth noted. These samples are currently frozen and could be analysed by EAL for the TP concentration if requested (see Discussion and Recommendations).

3 Results and Discussion

3.1 Phosphorus sorption capacity of wetland soils

Results of the P sorption capacity tests conducted by EAL are summarized in Table 3-1 with the detailed EAL results attached in Appendix A. The P sorption capacity of the mineral soils varied within each treatment cell and between the treatment cells.

In Cell D, the remaining P sorption capacity of the three soil samples collected along transect 1, transect 2, and transect 3 were 404, 425 and 796 kg P/ha, resulting in an average P sorption capacity of 542 kg P/ha. In terms of longitudinal spatial distribution, Cell D was the only cell to display a trend of increasing P sorption capacity. That is, the P sorption capacity was lowest at the inlet end of the cell (i.e. transect 1) and highest at the outlet end of the cell (transect 3).

At Cell E, the highest P sorption capacity was observed in the middle of the cell (Transect 2, 236 kg P/ha) whilst the lowest was observed at the outlet end of the cell (Transect 3, 152 kg P/ha). Overall, Cell E had the lowest average P sorption capacity (190 kg/ha) of the cells sampled. Cell E and Cell D are the first cells in the treatment train, that is, they receive effluent directly from the STP. However, the sorption capacities in Cell E are considerably lower, likely due to the topsoil used during the construction of the cell comprising of a sand and peat mixture.

Similarly to Cell D, Cell I reported the highest P sorption capacity at the outlet end of the cell (transect 3, 529 kg P/ha), however, the lowest sorption capacity was observed in the middle of the cell (transect 2, 179 kg P/ha). In theory, as Cell I follows Cell D in the treatment train, one would reasonably assume that its remaining P sorption capacity would be higher, yet, on average, Cell I had a P sorption capacity of 324 kg P/ ha, which is considerably lower than Cell D. This is likely due to Cell I being constructed from a paddock that used to receive effluent in the past and as such the soils have accumulated nutrients.

In Cell J, the P sorption capacities were similar amongst the three transects, ranging from 690 to 735 kg P/ha and averaging 712 kg P/ha. This is the highest of the cells studied and may be related to the high vegetative cover in the cell (discussed in Section 3.3)

Overall, the results suggest that the mineral soils in each of the treatment cells sampled have considerable capacity to continue to remove P from the treated wastewater. When accounting for cell size, the estimated areal weighted total sorption capacity for each cell is lowest at Cell E (304 kg P). Cell D and Cell I have similar remaining P sorption capacities of 975 and 1036 kg P, respectively, whilst Cell J has the highest remaining capacity with 2207 kg P. The estimates can be considered conservative given they are based on a soil depth of 15 cm, however, the actual depth of the mineral soil component is likely 30 to 40 cm.

Table 3-1 Results of the P sorption capacity tests of the mineral soils sampled at BBSTP treatment cells D, E, I and J. Average values for each treatment cell are shown. The depth of the accretive sediment layer at each sampling point is also shown.

Cell (area)	Transect	Sampling Point	Water Depth (mm)	Accretive sediment layer depth (mm)	P sorption capacity of soils to a depth of 15cm		
					Per Transect (kg P/ha)	Cell Average (kg P/ha)	Areal weighted total (kg P)*
D (1.8ha)	1	A	180	150	404	542	975
		B	125	190			
		C	65	160			
	2	A	100	250	425		
		B	210	260			
		C	120	230			
	3	A	140	190	796		
		B	215	90			
		C	230	130			
E (1.6ha)	1	A	285	190	181	190	304
		B	290	180			
		C	270	175			
	2	A	110	280	236		
		B	335	140			
		C	165	265			
	3	A	290	40	152		
		B	290	120			
		C	380	50			
I (3.2ha)	1	A	0	300	264	324	1036
		B	0	300			
		C	0	240			
	2	A	300	260	179		
		B	650	200			
		C	170	240			
	3	A	800	>2000	529		
		B	450	400			
		C	630	800			
J (3.1ha)	1	A	290	120	712	712	2207
		B	240	100			
		C	240	90			
	2	A	260	110	690		
		B	270	80			
		C	210	90			
	3	A	80	180	735		
		B	190	110			
		C	210	70			

*Calculated by multiplying the Cell Average (kg P ha) by the cell area (ha)

3.2 Accretive sediment layer assessment

As shown in Table 3-1, the depth of the accretive sediment layer in the BBSTP treatments cells varied within each treatment cell and between the treatment cells.

On average, the depth of the accretive sediment layer was similar in Cells D and E with 183 ± 57 mm and 160 ± 81 mm respectively.

The depth of the accretive sediment layer in Cell I averaged 527 ± 468 mm. This high average value, and the associated large standard deviation, was driven largely by the deep layer measured along transect 3 (> 2000mm) which occurred where the water depth was greatest (800 mm). Whilst this may suggest a relationship between water depth and the depth of the accretive sediment layer, no other such relationships were observed in the other cells.

In comparison to the other cells, the depth of the accretive sediments layer was very uniform throughout Cell J, averaging 106 ± 13 mm. Similarly, the P sorption capacity of the soils in Cell J was also very uniform throughout the cell in comparison to the other cells. The soils of Cell J also had the highest remaining P sorption capacity which may be related to the high vegetative cover which is discussed below.

Overall, the preliminary assessment of the accretive sediment layers suggests that the accretion of detrital organic matter/peat formation on the surface of the mineral soils appears to be an important P removal pathway in each of the treatment cells.

3.3 Vegetation assessment

There is variation in macrophyte cover within the wetland cells as detailed in Table 3-2 and illustrated in Figure 3-1 and Figure 3-2.

Cell D and Cell E show similar macrophyte coverage values; 64% and 60%, respectively. Cell D had the lowest average water depth of the cells (154 ± 37 mm) whilst the water depth in Cell E averaged 268 ± 59 mm.

Cell I and Cell J have quite different coverage between them when compared to Cell D and Cell E. Cell I had the lowest coverage with 41% cover which may be related to water depth as Cell I was considerably deeper (max depth 800mm) than the other cells.

Cell J has the highest vegetative cover with 96%. Interestingly, Cell J had the highest vegetation cover and also the highest cell average P sorption capacity in the mineral soil component tested (refer Table 3-1). This may suggest the high density of vegetation limits water access to the soil pores and thus P sorption. However there are many factors affecting these results and are inconclusive as Cell I which has the lowest vegetation cover does not have the lowest residual P Sorption capacity.

Table 3-2 Vegetation cover in BBSTP Wetland Cells

	Cell D	Cell E	Cell I	Cell J
Total cell area (m^2)	21291	19928	37683	37038
Total open water (m^2)	7702	8027	22379	1328
open water (%)	36%	40%	59%	4%
vegetation cover (%)	64%	60%	41%	96%

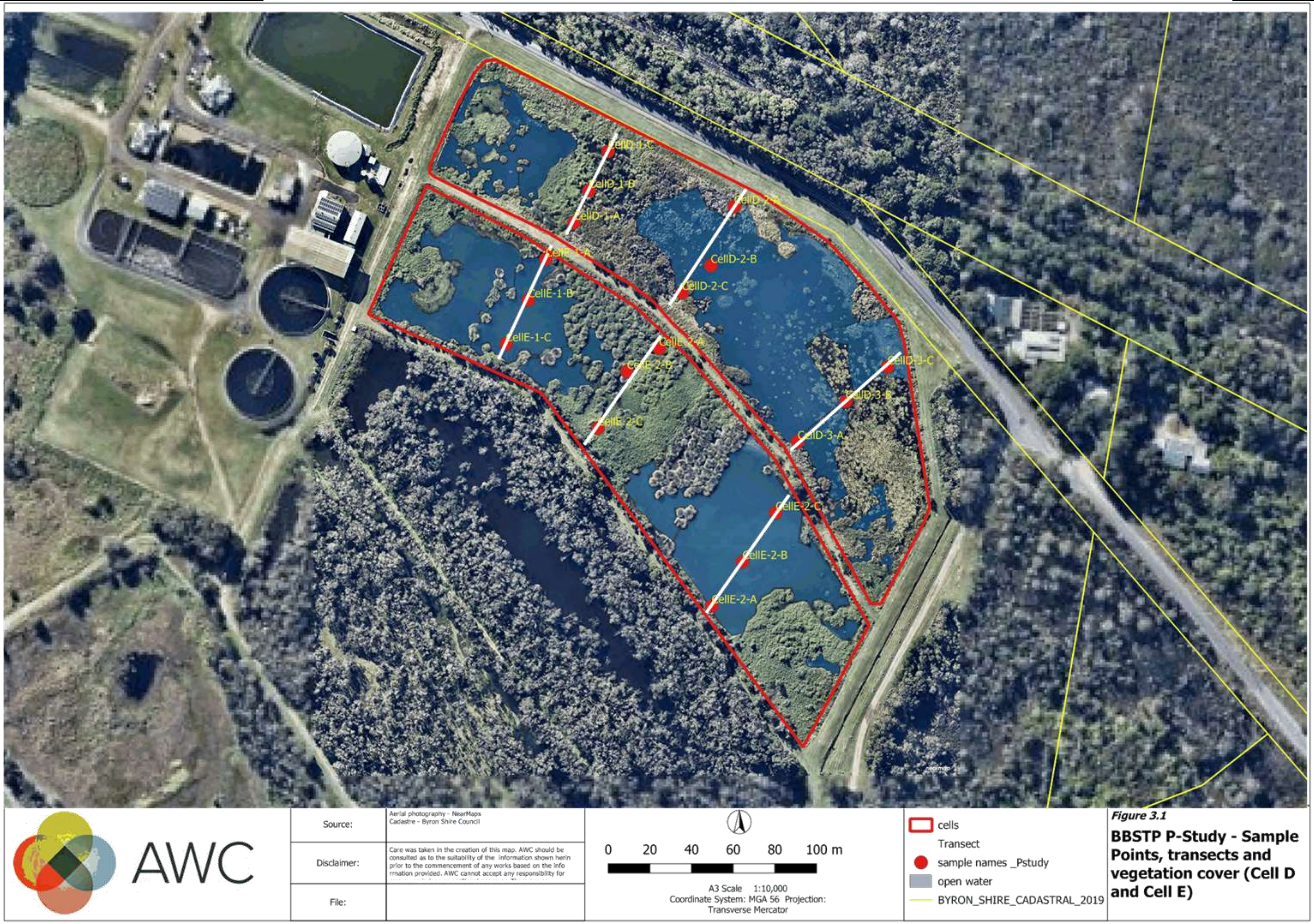
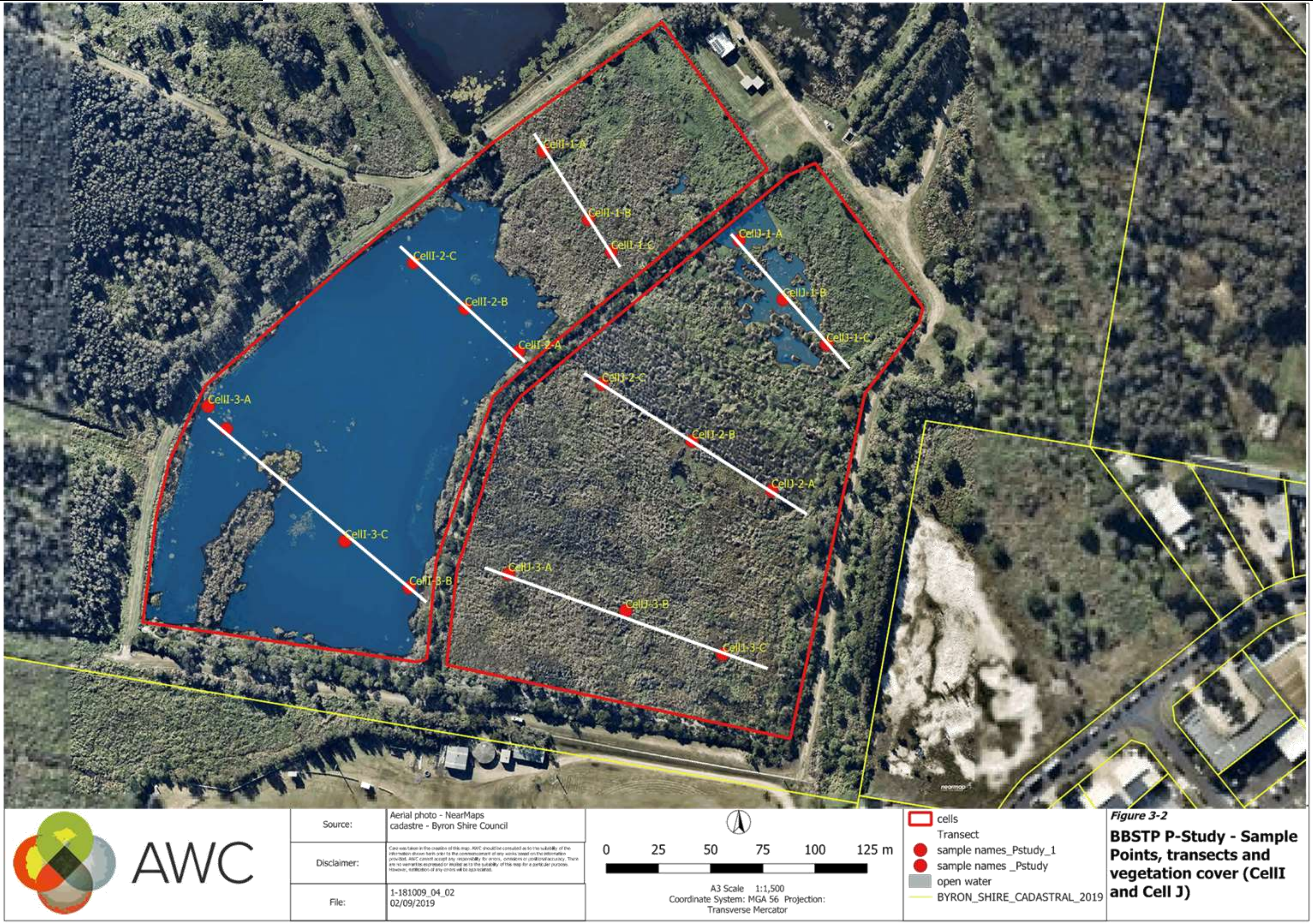


Figure 3.1

BBSTP P-Study - Sample Points, transects and vegetation cover (Cell D and Cell E)


CellI-1-A
CellI-1-B
CellI-1-C
CellI-2-C
CellI-2-B
CellI-2-A
CellI-3-A
CellI-3-C
CellI-3-B
CellJ-1-A
CellJ-1-B
CellJ-1-C
CellJ-2-C
CellJ-2-B
CellJ-2-A
CellJ-3-A
CellJ-3-B
CellJ-3-C
AWC
Source: Aerial photo - NearMaps cadastre - Byron Shire Council
Disclaimer:
File: 1-181009_04_02 02/09/2019
0 25 50 75 100 125 m
A3 Scale 1:1,500
Coordinate System: MGA 56 Projection: Transverse Mercator
cells
Transect
sample names_Pstudy_1
sample names _Pstudy
open water
BYRON_SHIRE_CADASTRAL_2019
Figure 3-2
BBSTP P-Study - Sample Points, transects and vegetation cover (CellI and Cell J)

4 Conclusions and Recommendations

This study revealed that the mineral soils in the FWS wetlands at BBSTP have considerable P sorption capacity remaining, however there is considerable variability between cells. Cell E has the lowest remaining P sorption capacity likely related to the sandy soils. Cell J has the highest remaining P sorption capacity which may be related to the high vegetative cover, suggesting that there is little vertical movement of surface water. That is, instead of the water infiltrating the sediments and percolating downward, the surface water predominantly flows laterally across the surface of the soils.

The preliminary assessment of the accretive sediment layer in each cell suggests that the accumulation of detrital organic matter/peat formation appears to be an important removal pathway. It is likely that this pathway is quantifiably significant in terms of its P content but it is beyond the scope of this study to estimate. Similarly, vegetation is a significant store of nutrients in treatment wetlands (Bedford *et al* 1999) and appears to be an important pathway at the BBSTP, however, it was also beyond the scope of this study to estimate the quantity of P stored in the vegetation.

Overall, this study achieved its primary objective. It is recommended that a long-term monitoring program designed to track and monitor changes in the P removal pathways over time (on the time-scale of years) be implemented. Such a study should aim to understand and identify any changes or issues which may diminish the performance of the P removal pathways and/or cause a release of P. Intermittent (3-5 years) sampling of soils to estimate the P sorption capacity as well as an assessment of vegetation biomass and accretive sediments is recommended.

If desired, a more detailed study on the cycling of P in the wetlands could include the estimation of the accreted detrital organic matter/peat from the analysis of the samples collected. A more thorough investigation could estimate the relative contribution of each removal pathway. This would help to identify how much P has been removed via chemical adsorption, versus accretion of organic sediments, and how much P is tightly bound vs weakly bound (and potentially reversible). Such a study would involve a more detailed analysis of bound P fractionation (e.g. Loosely Bound P, Fe and Al bound P, $CaCO_3$ associated P, Organic P).

5 References

Chen, H. (2011) *Surface-Flow Constructed Treatment Wetlands for Pollutant Removal: Applications and Perspectives* Wetlands Vol 31 Issue 4 pp 805-814

Jamieson et al (2001) *Phosphorus Adsorption Characteristics of a Constructed Wetland Soil Receiving Dairy Farm Wastewater* Canadian Journal of Soil Science 82 (1) pp 97-104

Kadlec, R.H. and Wallace, S.D. (2009) *Treatment Wetlands* CRC Press – Taylor and Francis Group Boca Raton USA

Penn et al. (2017) *A Review of Phosphorus Removal Structures: How to Assess and Compare their Performance* Water 9(8) p583.

Appendix A

EAL results of phosphorus sorption capacity tests

Notes to Appendix A:

The table below shows which transect the EAL Sample ID refers to.

EAL Sample ID	Transect
Sample 1	Cell D, Transect 1
Sample 2	Cell D, Transect 2
Sample 3	Cell D, Transect 3
Sample 4	Cell E, Transect 1
Sample 5	Cell E, Transect 2
Sample 6	Cell E, Transect 3
Sample 7	Cell I, Transect 1
Sample 8	Cell I, Transect 2
Sample 9	Cell I, Transect 3
Site 1	Cell J, Transect 1
Site 2	Cell J, Transect 2
Site 3	Cell J, Transect 3

WASTEWATER DISPOSAL SOIL ASSESSMENT

27(9) samples supplied by Australian Wetlands Consulting Pty Ltd on 29/7/19 - Lab Job No. I4250
Analysis requested by Jesse Munro. - **Your Project: 1-181009 - P Study**
8 George Street BANGALOW NSW 2479

	SAMPLE 1 Samples(1,2, 3)	SAMPLE 2 Samples(4,5, 6)	SAMPLE 3 Samples(7,8, 9)	SAMPLE 4 Samples(10, 11,12)	SAMPLE 5 Samples(13, 14,15)	SAMPLE 6 Samples(16, 17,18)	SAMPLE 7 Samples(19, 20,21)	SAMPLE 8 Samples(22, 23,24)	SAMPLE 9 Samples(25, 26,27)
Job No.	I4250/1	I4250/2	I4250/3	I4250/4	I4250/5	I4250/6	I4250/7	I4250/8	I4250/9
Native NaOH Phosphorus (mg/kg P)	1.27	0.57	0.93	0.71	1.13	0.67	0.81	0.31	0.69
Residual phosphorus remaining in solution from the initial phosphate phosphorus									
Initial Phosphorus concentration (ppm P)	**30.24**	**30.24**	**30.24**	**30.24**	**30.24**	**30.24**	**30.24**	**30.24**	**30.24**
72 hour - 3 Day (ppm P)	27.09	25.94	19.95	29.93	29.61	30.35	28.35	31.19	25.52
120 hour - 5 Day (ppm P)	26.04	25.41	19.85	29.09	28.25	29.72	27.93	30.56	25.20
168 hour - 7 Day (ppm P)	25.62	24.89	19.64	28.56	28.14	28.88	27.09	28.77	23.63
Equilibrium Phosphorus (ppm P)	24.50	24.23	19.47	27.61	26.82	28.03	26.44	27.63	22.85

Notes:

1: ECEC = Effective Cation Exchange Capacity = sum of the exchangeable Mg, Ca, Na, K, H and Al

2: Exchangeable bases determined using standard Ammonium Acetate extract (Method 15D3) with no pretreatment for soluble salts. When Conductivity ≥0.25 dS/m soluble salts are removed (Method 15E2).

3. ppm = mg/kg dried soil

4. Insitu P determined using 0.1M NaOH and shaking for 24 hrs before determining phosphate

5. Soils were crushed using a ceramic grinding head and mill; five 1g subsamples of each soil were used to which 40ml of 0.1M NaCl with Xppm phosphorus was added to each. The samples were shaken on an orbital shaker

6. Exchangeable sodium percentage (ESP) is calculated as sodium (cmol+/kg) divided by ECEC

7. All results as dry weight DW - soils were dried at 60C for 48hrs prior to crushing and analysis.

8. Phosphorus Capacity method from Ryden and Pratt, 1980.

9. Aluminium detection limit is 0.05 cmol+/kg; Hydrogen detection limit is 0.1 cmol+/kg. However for calculation purposes a value of 0 is used.

10. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm; EC_e conversions: sand loam 14, loam 9.5; clay loam 8.6; heavy clay 5.8

11. 1 cmol+/kg = 1 meq/100g

12. Emerson Aggregate Stability Test (EAST) for Wastewater applications (see Sheet 3 - Patterson, 2015). MEAT Class 1: Slaking, complete dispersion; Class 2: Slaking, some dispersion; Class 3-6: Slaking 1 slight to 3 complete, No dispersion; Class 7: No slaking, yes swelling; Class 8: No slaking, no swelling.

13. Analysis conducted between sample arrival date and reporting date.

14. .. Denotes not requested.

15. This report is not to be reproduced except in full.

16. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer scu.edu.au/eal or on request).

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PHOSPHORUS SORPTION TRIAL

27(9) samples supplied by Australian Wetlands Consulting Pty Ltd on 29/7/19 - Lab Job No. I4250

Analysis requested by Jesse Munro. - Your Project: 1-181009 - P Study

Calculations for Equilibrium Absorption Maximum for Soil provided

I.D.	JOB NO.	Equilibrium P mg P/L (in solution)	Added P mg P/L	P Sorb at Equil. mg P/kg	Native P mg P/kg	Equilibrium P Sorption Level µg P/g soil	Divide Ø (from Table)	Equilibrium Absorption Maximum (B) µg P/g soil
Samples(1,2,3)	**I4250/1**	24.5	30.24	229	1	231	0.93	**248**
Samples(4,5,6)	**I4250/2**	24.2	30.24	240	1	241	0.93	**260**
Samples(7,8,9)	**I4250/3**	19.5	30.24	431	1	432	0.89	**487**
Samples(10,11,12)	**I4250/4**	27.6	30.24	105	1	106	0.95	**111**
Samples(13,14,15)	**I4250/5**	26.8	30.24	137	1	138	0.95	**145**
Samples(16,17,18)	**I4250/6**	28.0	30.24	89	1	89	0.96	**93**
Samples(19,20,21)	**I4250/7**	26.4	30.24	152	1	153	0.94	**162**
Samples(22,23,24)	**I4250/8**	27.6	30.24	104	0	105	0.95	**110**
Samples(25,26,27)	**I4250/9**	22.8	30.24	296	1	296	0.92	**324**

Calculations for phosphorus sorption capacity

	JOB NO.	Equilibrium Absorption Maximum (B) µg P/g soil	multiply by theta of wastewater to be applied (=X)	minus the native P (=Y)	**kg P sorption / hectare (to a depth of 15cm)** (1.95 is a correction factor for density, etc)	**kg P sorption / hectare (to a depth of 100cm)** (1.95 is a correction factor for density, etc)
Samples(1,2,3)	I4250/1	248	(=B x theta)	(=X -native P)	(=Y x 1.95)	(=Y x 1.95 x 100/15)
Samples(4,5,6)	I4250/2	260	(=B x theta)	(=X - native P)	(=Y x 1.95)	(=Y x 1.95 x 100/15)
Samples(7,8,9)	I4250/3	487	(=B x theta)	(=X -native P)	(=Y x 1.95)	(=Y x 1.95 x 100/15)
Samples(10,11,12)	I4250/4	111	(=B x theta)	(=X - native P)	(=Y x 1.95)	(=Y x 1.95 x 100/15)
Samples(13,14,15)	I4250/5	145	(=B x theta)	(=X - native P)	(=Y x 1.95)	(=Y x 1.95 x 100/15)
Samples(16,17,18)	I4250/6	93	(=B x theta)	(=X - native P)	(=Y x 1.95)	(=Y x 1.95 x 100/15)
Samples(19,20,21)	I4250/7	162	(=B x theta)	(=X - native P)	(=Y x 1.95)	(=Y x 1.95 x 100/15)
Samples(22,23,24)	I4250/8	110	(=B x theta)	(=X - native P)	(=Y x 1.95)	(=Y x 1.95 x 100/15)
Samples(25,26,27)	I4250/9	324	(=B x theta)	(=X -native P)	(=Y x 1.95)	(=Y x 1.95 x 100/15)

EXAMPLE 1 - Calculations for phosphorus sorption capacity using a wastewater phosphorus of 15mg/L P

	JOB NO.	Equilibrium Absorption Maximum (B) µg P/g soil	multiply by theta of wastewater to be applied (ie. 0.84)	minus the native P (=Y)	**kg P sorption / hectare (to a depth of 15cm)** (1.95 is a correction factor for density, etc)	**kg P sorption / hectare (to a depth of 100cm)** (1.95 is a correction factor for density, etc)
Samples(1,2,3)	I4250/1	248	209	207	**404**	**2,694**
Samples(4,5,6)	I4250/2	260	218	218	**425**	**2,830**
Samples(7,8,9)	I4250/3	487	409	408	**796**	**5,309**
Samples(10,11,12)	I4250/4	111	93	93	**181**	**1,205**
Samples(13,14,15)	I4250/5	145	122	121	**236**	**1,573**
Samples(16,17,18)	I4250/6	93	78	78	**152**	**1,011**
Samples(19,20,21)	I4250/7	162	136	135	**264**	**1,758**
Samples(22,23,24)	I4250/8	110	92	92	**179**	**1,196**
Samples(25,26,27)	I4250/9	324	272	271	**529**	**3,526**

Environmental Analysis Laboratory, Southern Cross University,
Tel. 02 6620 3678, website: scu.edu.au/eal

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WASTEWATER DISPOSAL SOIL ASSESSMENT

3 samples supplied by Australian Wetlands Consulting Pty Ltd on 5/8/19 - Lab Job No. i4474
Analysis requested by Jesse Munro. - **Your Project: 1-181009_Pstudy**
(8 George Street BANGALOW NSW 2479).

	SITE 1 **Composite Cell J-1**	SITE 2 **Composite Cell J-2**	SITE 3 **Composite Cell J-3**
Job No.	*i4474/C1*	*i4474/C2*	*i4474/C3*
Native NaOH Phosphorus (mg/Kg P)	205	311	86
Residual phosphorus remaining in solution from the initial phosphate phosphorus			
Initial Phosphorus concentration (ppm P)	**31.3**	**31.3**	**31.3**
72 hour - 3 Day (ppm P)	25.70	24.80	25.90
120 hour - 5 Day (ppm P)	25.30	23.70	23.80
168 hour - 7 Day (ppm P)	22.40	22.60	23.20
Equilibrium Phosphorus (ppm P)	21.13	21.23	21.04

Notes:

1. ppm = mg/Kg dried soil
2. Insitu P determined using 0.1M NaOH and shaking for 24 hrs before determining phosphate
3. Soils were crushed using a ceramic grinding head and mill; five 1g subsamples of each soil were used to which 40ml of 0.1M NaCl with Xppm phosphorus was added to each. The samples were shaken on an orbital shaker
4. All results as dry weight DW - soils were dried at 40degC for 48hrs prior to crushing and analysis.
5. Phosphorus Capacity method from Ryden and Pratt, 1980.
6. Analysis conducted between sample arrival date and reporting date.
7. ** NATA accreditation does not cover the performance of this service.
8. .. Denotes not requested.
9. This report is not to be reproduced except in full.
10. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer scu.edu.au/eal or on request).

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Environmental Analysis Laboratory, Southern Cross University,
Tel. 02 6620 3678, website: scu.edu.au/eal

checked: ....

PHOSPHORUS SORPTION TRIAL

3 samples supplied by Australian Wetlands Consulting Pty Ltd on 5/8/19 - Lab Job No. i4474

Analysis requested by Jesse Munro. - Your Project: 1-181009_Pstudy

Calculations for Equilibrium Absorption Maximum for Soil provided

I.D.	JOB NO.	Equilibrium P mg P/L (in solution)	Added P mg P/L	P Sorb at Equil. mg P/Kg	Native P mg P/Kg	Equilibrium P Sorption Level µg P/g soil	Divide Ø (from Table)	Equilibrium Absorption Maximum (B) µg P/g soil
Composite Cell J-1	**i4474/C1**	21.13	31.3	407	204.80	611	0.90	**679**
Composite Cell J-2	**i4474/C2**	21.23	31.3	403	311.20	714	0.90	**792**
Composite Cell J-3	**i4474/C3**	21.04	31.3	410	85.60	496	0.90	**551**

Calculations for phosphorus sorption capacity

	JOB NO.	Equilibrium bsorption Maximum (B µg P/g soil	multiply by theta of astewater to be applie (=X)	minus the native P (=Y)	**Kg P sorption / hectare (to a depth of 15cm)** (1.95 is a correction factor for density, etc	**Kg P sorption / hectare (to a depth of 100cm)** (1.95 is a correction factor for density, etc)
Composite Cell J-1	*i4474/C1*	679	(=B x theta)	(=X -native P)	(=Y x 1.95)	(=Y x 1.95 x 100/15)
Composite Cell J-2	*i4474/C2*	792	(=B x theta)	(=X - native P)	(=Y x 1.95)	(=Y x 1.95 x 100/15)
Composite Cell J-3	*i4474/C3*	551	(=B x theta)	(=X -native P)	(=Y x 1.95)	(=Y x 1.95 x 100/15)

EXAMPLE 1 - Calculations for phosphorus sorption capacity using a wastewater phosphorus of 15mg/L P

	JOB NO.	Equilibrium bsorption Maximum (B µg P/g soil	multiply by theta of astewater to be applie (ie. 0.84)	minus the native P (=Y)	**Kg P sorption / hectare (to a depth of 15cm)** (1.95 is a correction factor for density, etc	**Kg P sorption / hectare (to a depth of 100cm)** (1.95 is a correction factor for density, etc)
Composite Cell J-1	*i4474/C1*	679	570	365	**712**	**4,747**
Composite Cell J-2	*i4474/C2*	792	665	354	**690**	**4,600**
Composite Cell J-3	*i4474/C3*	551	463	377	**735**	**4,903**

Environmental Analysis Laboratory, Southern Cross University,
Tel. 02 6620 3678, website: scu.edu.au/eal

Checked:..........

Bangalow

8 George Street
Bangalow NSW 2479
P 02 6687 1550
info@awconsult.com.au

www.awconsult.com.au

Technical Memorandum

To:	Bryan Green, Claudio Germany, Cameron Clark (BSC)
From:	Jesse Munro, Mitchell Call (AWC)
Date:	3 October 2019
Pg/Attach.:	6
Job ref:	1-191162_BBSTP_Pyrite_Testing.docx

BBSTP – 24ha irrigation area – pyrite testing

Acid sulfate soils (ASS) contain microscopic crystals of iron sulphide minerals, the most common being pyrite. Sulfide-reducing bacteria create pyrite (FeS_2) from sulfate (SO_4^{2-}) and iron (Fe^{2+}) that is present in soils subject to anaerobic, waterlogged conditions with a sufficient supply of organic matter. Left undisturbed, the pyrite is largely harmless, slowly oxidising and allowing acidophilic ecosystems to form. However, if ASS are exposed to oxygen by means of excavation or drainage, the oxidation of pyrite in the soil is accelerated, producing excess sulfuric acid and mobilising dissolved metals such as aluminium and iron. Rainfall or irrigation can flush the acid and dissolved metals from the soil into receiving aquatic environments, posing a significant environmental risk.

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8 George St
Bangalow NSW 2479

p. (02) 6687 1550
e. info@awconsult.com.au
w. awconsult.com.au

Pyrite occurs heterogeneously throughout the peat soil profile of the Byron Bay Sewage Treatment Plan (BBSTP) 24ha irrigation site, varying both vertically and laterally. The *Byron Effluent Reuse Wetland Scientific Report* (Bolton, 2006) identified two distinct pyrite layers that occur within the peat profile:

1. Subsurface pyrite layer: located at depths of 80 cm or lower, this layer ranges from 20-60cm in thickness and formed more than 5000 years ago when sea levels were ~ 1m higher than present and the area was an inland estuary high in sulfate, iron and organic matter. This layer represents a significant store of potential acidity across the 24ha site

2. Surface pyrite layer: located close to the surface of the peat layer and generally only 5cm thick. This layer formed over a period of months to years (rather than millennia) and only occurs in areas of the 24ha site that had been recently waterlogged with tertiary treated effluent. Whilst this layer contains a lesser store of potential acidity compared to the subsurface layer, its surface location makes it prone to oxidation.

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Bolton (2006) concluded that the top 2 m of the 24 ha irrigation site contains actionable levels of sulphide (i.e. pyrite) that requires an ASS management plan to mitigate the adverse environmental impacts of severe acidity. As stated in Bonner (2006), the 24ha irrigation area is an effluent reuse area and subject to drainage and is inevitable that pyrite formation will occur and unrealistic to expect that pyrite oxidation could be prevented. Both processes can occur simultaneously at various locations and depths across the 24ha site which poses important ASS management considerations that are outlined in the *Effluent Reuse and Wetland Regeneration [24ha site]: Operational & Management Guidelines* (Bonner, 2007). As such, Bonner (2007) recommended a water table management regime that aims to:

1. Prevent oxidation of the main subsurface pyrite later
2. Minimise formation of pyrite in the surface layer
3. Minimise export of toxic oxidation products to the Belongil Estuary

In order to monitor the status of the ASS in the 24 ha, in particular the formation of pyrite in the surface layer, Bonner (2007) recommended a soil monitoring program to assess if the ASS management techniques are succeeding. However, there is no indication that this monitoring has been undertaken at the 24 ha irrigation site since commissioning.

This Technical Memorandum presents the results from soil tests that aimed to detect an increase in pyrite content in the surface layer of soils (top 40 cm) that occur in the 24ha site as recommended in the *Effluent Reuse and Wetland Regeneration [24ha site]: Operational & Management Guidelines* (Bonner, 2007).

Methods

As suggested by Bonner (2007), soil samples were collected in close proximity to areas that were tested previously by Bolton (2006) and nearby to groundwater monitoring bores. Figure 1 shows the location of the three sampling sites: a waterlogged site; an irrigated site; and a non-irrigated site. Soil samples were extracted as a complete core using a hand-held soil sampler and discrete samples collected at the following intervals: 0-5 cm, 5-10 cm, 10-15 cm, 15-20 cm, 20-30 cm and 30-40 cm. Discrete samples were stored on ice after collection then stored in the freezer until analysis. Four soil cores were extracted at each site and the depth intervals composited and analysed for Chromium Reducible Sulfur (CRS) by Environmental Analysis Laboratory (EAL) at SCU in Lismore. CRS is used to determine the concentration of iron sulphide (i.e. pyrite) in soils and expressed as % S_{CR}.

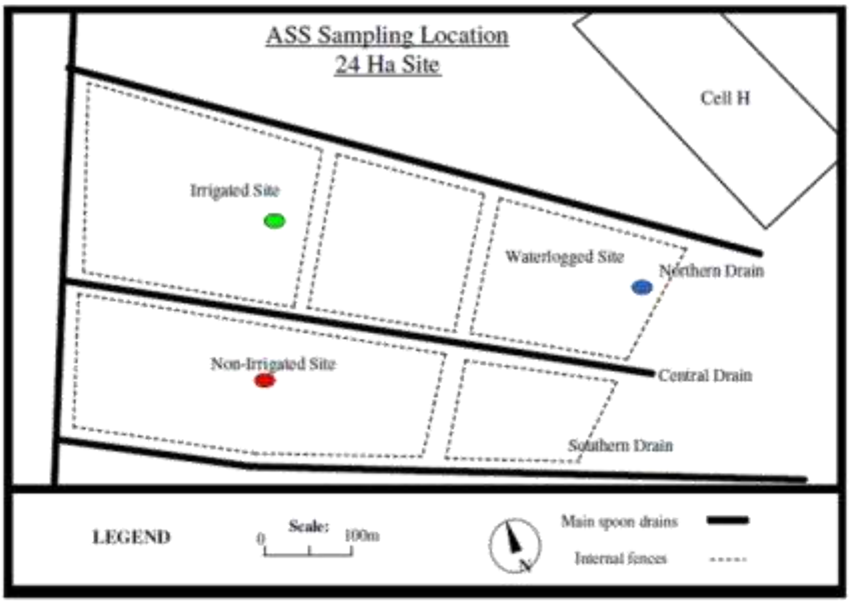

Figure 1 Location of the Waterlogged, Irrigated, and Non-irrigated soil sampling sites. Source Bonner (2007)

Results

Results of the soils tests are summarised in Table 1 with the detailed EAL results attached in Appendix A. The CRS content of the soils sampled was highest at the waterlogged site, ranging from 0.083 to 0.17 % S_{CR} and averaging 0.109 % S_{CR}. The CRS content was lowest at the irrigated site, ranging from 0.038 to 0.085 % S_{CR} and averaging 0.052 % S_{CR}. At the non-irrigated site, CRS concentrations ranged from 0.06 to 0.096 % S_{CR} and averaged 0.068 % S_{CR}. The maximum CRS concentration at each site occurred in the 0-5 cm soil interval. The distribution of CRS concentrations at the irrigated site displayed a decreasing trend with depth, whilst the CRS distribution at the waterlogged and non-irrigated sites was more heterogeneous.

AWC

Table 1 Chromium Reducible Sulfur (CRS) content per soil interval for the Waterlogged, Irrigated, and Non-Irrigated sites

	Chromium Reducible Sulfur (CRS) concentration [% S_{CR}]		
Soil Interval (cm)	Waterlogged Site	Irrigated Site	Non-Irrigated Site
0-5	0.170	0.085	0.096
5-10	0.103	0.054	0.060
10-15	0.083	0.047	0.060
15-20	0.091	0.047	0.065
20-30	0.103	0.044	0.060
30-40	0.101	0.038	0.069

Conclusion

Bolton (2006) recommends that the water table be lowered should surface pyrite concentrations exceed 0.15% S_{CR}. The average concentrations of CRS (i.e. pyrite) in the top 40 cm of the soils sampled in this study were all below the 0.15% S_{CR} trigger. The concentration observed in the 0-5cm interval of the waterlogged site was 0.17 % S_{CR}, suggesting that surface water ponding, either permanently or intermittently, may be occurring at this site resulting in the formation of pyrite. Bolton (2006) suggested surface pyrite forms more rapidly in areas where water pools above the ground surface, thus management should avoid this occurring at the waterlogged site.

The results from this study are largely in-line with the CRS observations reported by Bolton (2006). Bolton (2006) reported a decline in average CRS concentrations from 0.5 to ~ 0.1%S_{CR} at the waterlogged site over an 18 month monitoring period following drainage works. In this current study, the average CRS concentration at the waterlogged site was 0.109 % S_{CR}. During the same monitoring period, Bolton (2006) reported an increase in CRS concentration from 0.05 to ~0.1 % S_{CR} at the irrigated site whilst the non-irrigated site remained at ~ 0.05 % S_{CR}. In comparison, the average concentrations in this current study were 0.052 % S_{CR} at the irrigated site and 0.068 % S_{CR} at the non-irrigated site.

Overall, this study suggests that the pyrite content in the surface layer at all three sites has remained largely stable since 2006. It is recommended that the study be repeated annually and that a separate study investigating the pyrite content spanning the full soil profile (to 200 cm depth) be conducted concurrently.

References

Bolton, K.G.E (2006). *The Byron Effluent Reuse Wetland Scientific Report. Consultancy report prepared for Byron Shire Council.* Southern Cross University and Ecotechnology Australia.

Bonner, D (2007). *Effluent Reuse and Wetland Regeneration [24ha site]: Operational & Management Guidelines* Byron Shire Council.

Appendix A

Notes to Appendix A:

The table below shows which site and soil interval the EAL Sample Identification refers to.

EAL Sample ID	Site and Soil Interval
Site-IR-1	Irrigated Site 0-5cm
Site-IR-2	Irrigated Site 5-10cm
Site-IR-3	Irrigated Site 10-15cm
Site-IR-4	Irrigated Site 15-20cm
Site-IR-5	Irrigated Site 20-30cm
Site-IR-6	Irrigated Site 30-40cm
Site-W-1	Waterlogged Site 0-5cm
Site-W-2	Waterlogged Site 5-10cm
Site-W-3	Waterlogged Site 10-15cm
Site-W-4	Waterlogged Site 15-20cm
Site-W-5	Waterlogged Site 20-30cm
Site-W-6	Waterlogged Site 30-40cm
Site-D-1	Non-Irrigated Site 0-5cm
Site-D-2	Non-Irrigated Site 5-10cm
Site-D-3	Non-Irrigated Site 10-15cm
Site-D-4	Non-Irrigated Site 15-20cm
Site-D-5	Non-Irrigated Site 20-30cm
Site-D-6	Non-Irrigated Site 30-40cm

PAGE 1 OF 1

RESULTS OF ACID SULFATE SOIL ANALYSIS

72 samples supplied by Australian Wetlands Consulting Pty Ltd on 30th September, 2019. Lab Job No. I6258
Samples were combined by EAL into 18 composite samples prior to analysis.
Analysis requested by Jesse Munro. Your Job: 1-181009_Pyrite Study

[illegible]

Sample Identification	Depth	EAL Lab Code	Texture	Moisture Content		Potential Sulfidic Acidity (Chromium Reducible Sulfur - CRS)	
	(m)			(% moisture of total wet weight)	(g moisture / g of oven dry soil)	(% S_{Cr})	(mol H^+/t)
[illegible]							
Site-IR-1 (A-D)	0-0.05	I6258/C1	Medium	73.1	2.72	0.085	53
Site-IR-2 (A-D)	0.05-0.1	I6258/C2	Medium	82.1	4.57	0.054	33
Site-IR-3 (A-D)	0.1-0.15	I6258/C3	Medium	83.3	4.99	0.047	29
Site-IR-4 (A-D)	0.15-0.2	I6258/C4	Medium	85.4	5.84	0.047	29
Site-IR-5 (A-D)	0.2-0.3	I6258/C5	Medium	86.3	6.29	0.044	27
Site-IR-6 (A-D)	0.3-0.4	I6258/C6	Medium	87.6	7.04	0.038	24
Site-W-1 (A-D)	0-0.05	I6258/C7	Medium	73.8	2.81	0.170	106
Site-W-2 (A-D)	0.05-0.1	I6258/C8	Medium	78.4	3.62	0.103	64
Site-W-3 (A-D)	0.1-0.15	I6258/C9	Medium	83.7	5.13	0.083	52
Site-W-4 (A-D)	0.15-0.2	I6258/C10	Medium	86.1	6.21	0.091	57
Site-W-5 (A-D)	0.2-0.3	I6258/C11	Medium	88.3	7.52	0.103	64
Site-W-6 (A-D)	0.3-0.4	I6258/C12	Medium	88.8	7.96	0.101	63
Site-D-1 (A-D)	0-0.05	I6258/C13	Medium	75.9	3.15	0.096	60
Site-D-2 (A-D)	0.05-0.1	I6258/C14	Medium	82.6	4.74	0.060	37
Site-D-3 (A-D)	0.1-0.15	I6258/C15	Medium	83.6	5.11	0.060	37
Site-D-4 (A-D)	0.15-0.2	I6258/C16	Medium	84.1	5.28	0.065	41
Site-D-5 (A-D)	0.2-0.3	I6258/C17	Medium	84.0	5.27	0.060	37
Site-D-6 (A-D)	0.3-0.4	I6258/C18	Medium	85.4	5.84	0.069	43

NOTES:

1. All analysis is reported on a dry weight (DW) basis, unless wet weight (WW) is specified.
2. Samples are dried and ground immediately upon arrival (unless supplied dried and ground).
3. Analytical procedures are sourced from Sullivan L, Ward N, Toppler N and Lancaster G. 2018. National acid sulfate soils guidance: national acid sulfate soils identification and laboratory methods manual, Department of Agriculture and Water Resources, Canberra, ACT. CC BY 4.0.
4. The Acid Base Accounting Equation, where Acid Neutralising Capacity has not been corroborated by other data, is **Net Acidity = Potential Acidity + Actual Acidity + Retained Acidity** (Eq. 3.2; Sullivan et al. 2018 - full reference above).
5. The Acid Base Accounting Equation for post-limed soil materials is **Net Acidity = Potential Acidity + Actual Acidity + Retained Acidity - (post treatment Acid Neutralising Capacity - initial Acid Neutralising Capacity)** (Eq. 3.3; Sullivan et al. 2018 - full reference above).
   While the Acid Neutralising Capacity of a soil material may not be included in the Net Acidity calculation (Note 4), it must be measured to give an Initial Acid Neutralising Capacity if verification testing is planned post-liming.
   The initial Acid Neutralising Capacity must be provided by the client to enable EAL to produce Verification Net Acidity and Liming calculations for post-limed soil materials.
6. The Acid Base Accounting Equation, where Acid Neutralising Capacity has been corroborated by other data, is Net Acidity = Potential Acidity + Actual Acidity + Retained Acidity - Acid Neutralising Capacity (Eq. 3.1; Sullivan et al. 2018 - full reference above).
7. The lime calculation includes a Safety Factor of 1.5 as a safety margin for acid neutralisation (Sullivan et al. 2018). This is only applied to positive values. An increased Safety Factor may be required in some cases.
8. Retained Acidity is required when the pH_{KCl} < 4.5 or where jarosite has been visually observed.
9. A negative Net Acidity result indicates an excess acid neutralising capacity.
10. If insufficient mixing occurs during initial sampling, or during post-liming, or both: the Potential Sulfidic Acidity may be greater in the post-limed sample than in the initial sample; the post-liming Acid Neutralising Capacity may be lower in the post-limed sample than in the initial sample.
11. **An acid sulfate soil management plan is triggered by Net Acidity results greater than the texture dependent criterion: coarse texture ≥ 0.03% S or 18 mol H^+/t; medium texture ≥ 0.06% S or 36 mol H^+/t; fine texture ≥ 0.1% S or 62 mol H^+/t)** (Table 1.1; Sullivan et al. 2018 - full reference above)
12. For projects that disturb > 1000 t of soil material, the coarse trigger of ≥ 0.03% S or ≥ 18 mol H^+/t must be applied in accordance with Sullivan et al. (2018) (full reference above).
13. Acid sulfate soil texture triggers can be related to NCST (2009) textures: coarse and peats = sands to loamy sands; medium = clayey sand to light clays; fine = light medium to heavy clays (Sullivan et al. 2018 - full reference above).
14. Bulk density is required to convert liming rates to soil volume based results. Field bulk density rings can be submitted to EAL for bulk density determination.
15. A negative Net Acidity result indicates an excess acid neutralising capacity.
16. '..' is reported where a test is either not requested or not required. Where pH_{KCl} is < 4.5 or > 6.5, zero is reported for S_{NAS} and ANC in Net Acidity calculations, respectively.
17. Results refer to samples as received at the laboratory. This report is not to be reproduced except in full.
18. **NATA accreditation does not cover the performance of this service.
19. Analysis conducted between sample arrival date and reporting date.
20. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer scu.edu.au/eal or on request).
21. Results relate to the samples tested.
22. This report was issued on 01/10/2019.

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checked: ....
Graham Lancaster
Laboratory Manager

Environmental Analysis Laboratory, Southern Cross University,
Tel. 02 6620 3678, website: scu.edu.au/eal