

Causes of declining ecosystem health grades in the Pumicestone Passage

Findings of the Pumicestone Passage Technical Working Group



Final version
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Executive summary

The Pumicestone Passage is a valuable ecological and recreational waterway, extending 45km between Bribie Island and the mainland in South East Queensland. It boasts extensive mangroves, intertidal mudflats, migratory bird populations, dugong, turtles and dolphins, and is protected under state, national and international agreements and legislative instruments.

Healthy Waterways and partners have monitored the health of the Pumicestone Passage and its freshwater catchment since 2000, through the regional Ecosystem Health Monitoring Program. Annual report card assessments for the Passage and its freshwater catchment have generally been 'fair' to 'good', but have declined since 2006 in the Passage itself, to 'poor' in 2010.

In response, local and regional partners convened the Pumicestone Passage Technical Working Group, to:

1. investigate emerging issues relevant to the Passage's declining health, and
2. recommend response actions to be implemented through local government plans.

The group achieved the first objective through four workshops conducted between February and May 2011, which included presentations by technical specialists. This report is the culmination of the second objective.

Numerous issues were discussed and technical information was presented at the workshops or disseminated out of session. At the end of the process, issues were grouped under 'condition', 'pressure' or 'management' themes and ranked according to their significance with respect to measured declines in the health of the Passage (Table ES1).

Table ES1. High-significance issues and learnings

Issue	Significance	Learnings
<i>Condition</i>		
Increased nitrogen in central-northern Passage	High—Consistent increases have driven recent report card declines	<ul style="list-style-type: none"> • Total nitrogen has increased in central-northern Passage since 2008, driven by increasing dissolved nitrogen concentrations • Highest concentrations near Coochin Ck mouth • Increases due to higher inputs from northern tributaries, not net northward accumulation
Nutrient hot-spot area in northern freshwater subcatchments	High—Relevant to pinpointing source of increasing nutrients	<ul style="list-style-type: none"> • Very high oxidised nitrogen concentrations in middle-upper Coochin Ck and Back Ck; rural area around Beerwah
<i>Key pressures</i>		
Nutrient and sediment runoff from agricultural land use	High—Potentially the key driver of increasing nutrient loads	<ul style="list-style-type: none"> • Increasing intensity and variety of agricultural land-use over past 3–5 years • Less cane and horticulture; more pineapples, turf, strawberries and chickens

Issue	Significance	Learnings
Nutrient and sediment runoff from proposed Caloundra South development	Moderate—May increase local nutrient concentrations	<ul style="list-style-type: none"> • Beyond best practice required to maintain water quality in Passage • Stockland modelling indicates no notable nutrient increases expected in Passage but local phosphorus increases in Bells Ck
Nutrient, sediment and pathogen runoff from other diffuse sources	Moderate—Expect some localised contaminant contributions	<ul style="list-style-type: none"> • Some nutrient, sediment and pathogen contributions expected from on-site sewage systems, reticulated sewerage and forestry areas • Overall loads not expected to be major
<i>Management</i>		
Limited adherence to rural best management practices	High—Relevant to management of increasing nutrient loads	<ul style="list-style-type: none"> • Some agricultural activities (e.g. pineapple farming) have <30% uptake of best management practice with Pumicestone Passage catchment

Conclusions

Key conclusions of the group were as follows:

- The priority issue with respect to recent declines in report card grades is increased concentrations of nitrogen, driven by unusually high oxidised nitrogen, in the central to northern section of the Passage.
- Nitrogen increases are not merely the result of increased runoff due to increased rainfall in recent years. Further, the exceedence of nitrogen guidelines at some sites is not merely the result of an inappropriate choice of guidelines. There is a real issue of high and increasing nitrogen concentrations in the northern Passage, above and beyond these potential artefacts.
- High nitrogen concentrations in the northern Passage are due to disproportionately high inputs from Coochin Creek, which discharges into the central-northern Passage; rather than accumulation from net northerly flow from uniform contributions throughout the catchment.
- In particular, significant loads of oxidised nitrogen are being generated by the predominantly agricultural area of upper Coochin Creek and Back Creek, near Beerwah.
- Increasing nitrogen loads from within the Coochin Creek subcatchment are probably due to intensification of agricultural activities during recent years and non-compliance with best management practice, but more information is required to pinpoint specific land-uses that are generating the greatest loads.
- On-site sewage systems (septics), forestry, reticulated sewerage leaks or overflows and the proposed Caloundra South urban development are other potentially-significant sources of nutrients and other contaminants to the northern Pumicestone Passage.

Recommendations

Key recommendations of the group were as follows (with priority indicated):

1. Design and implement a targeted local monitoring project that complements existing programs and informs development of a nutrient mass balance and estimation of export loads from key land uses. In addition, monitor extra estuarine EHMP sites in estuaries of the Passage, to confirm which tributaries export the greatest nutrient loads. (**High priority**)

2. Undertake further investigation into the interpretation of $\delta^{15}\text{N}$ data. In the meantime, spatially-intensive measurements of water column nitrogen are preferred for nitrogen source tracking. (Low priority)
3. Use updated catchment and receiving water quality models and land-use mass balances for the Pumicestone Passage to evaluate potential management strategies in terms of their expected effects on water quality and ecological health. (High priority)
4. Develop a single, accurate land-use map of the Pumicestone Passage catchment. (High priority)
5. Implement regulatory and incentive-based measures to ensure adequate erosion and sediment control during the construction phase of any new developments in the catchment, in particular, large-scale developments such as Caloundra South. (Moderate priority)
6. Develop a mass balance for nutrient, sediment and pathogen loads generated from the catchment by agricultural activities, especially pineapple, strawberry, turf and chicken farms and unsealed roads, to identify the major contributors. (High priority)
7. Implement incentive-based and regulatory measures to improve management of agricultural activities within the catchment, in particular, pineapple, strawberry, turf and chicken farming and waste disposal. (High priority)
8. Liaise with Australia Zoo to determine the quantity of any nutrient loads released to Bluegum Creek or other streams, and assist implementation of improved practices if required. (Low priority)
9. Initiate on-ground projects to mitigate impacts from unsealed roads. (Moderate priority)
10. Develop a management plan and compliance program for 4-wheel-drive vehicles within forestry and other areas. (Moderate priority)

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1 Introduction

The Pumicestone Passage (the Passage) is a tidal waterway between the mainland on the west and Bribie Island to the east (Figure 1). The mainland catchment drains eastward from the D’Aguilar Range via Bells, Mellum-Coochin, Tibrogargan-Hussey, Elimbah and Ningi Creeks and other minor streams. The Passage and its catchment have high environmental values, diverse land uses and complex management arrangements. The Passage is highly valued for its extensive mangrove, seagrass and mudflat habitats, aquatic fauna such as fish, dugong, turtles and migratory shorebirds and recreational opportunities such as fishing, swimming and boating. Its catchment supports diverse rural land-uses, including extensive tracts of forestry and agriculture such as pineapple, strawberry and poultry farms; as well as notable areas of natural bush, established urban areas and major areas of urban expansion. The Passage itself is a Ramsar wetland—with associated national and international management responsibilities—and is a Marine Park, Fish Habitat Area and High Ecological Value area under State legislation. A pivotal challenge in managing the Passage and its catchment is collaboration between different sectors to respect and protect its diverse values and uses, within this complex management context.

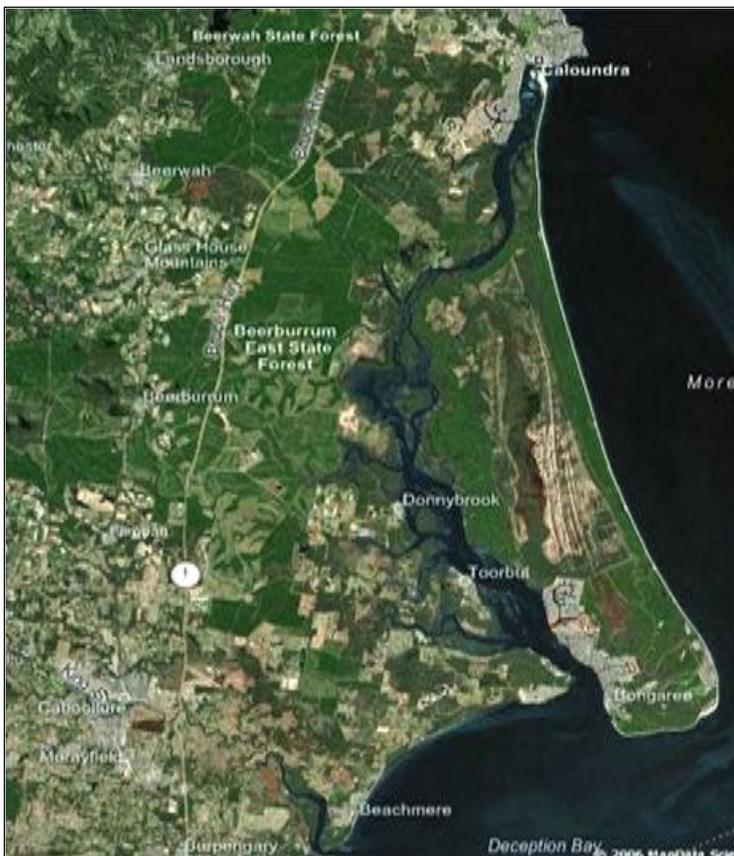


Figure 1: Pumicestone Passage and its catchment

A recent decline in water quality and general ecosystem health in the Passage has caused Sunshine Coast Council (SCC) and Moreton Bay Regional Council (MBRC) to come together and approach Healthy Waterways to coordinate and facilitate the *Pumicestone Passage Technical Working Group* (PPTWG). Both councils are most interested in key contemporary issues relating to water quality and ecosystem health decline in the Passage. Findings of the PPTWG will inform a Catchment & Estuary Management Plan (CEMP) being developed by SCC and a Total Water Cycle Management Plan (TWCMP) being developed by MBRC. This report summarises scientific

knowledge on key current issues and their implications, and provides recommendations for catchment and water cycle management. These outputs will inform councils' decision-making process with respect to activities that improve the water quality of the Passage.

1.1 Charter

A charter was established to facilitate the coordination of the PPTWG. Key elements such as purpose, outputs and governance arrangements of the group were discussed, and a summary of the final charter is given below.

Key purpose and scope

- Facilitate the compilation and interpretation of technical information on key emerging catchment management and waterway health issues in the Pumicestone Passage;
- Facilitate use of that information to inform MBRC's Total Water Cycle Management Plan (TWCMP) and SCC's Catchment and Estuary Management Plan (CEMP).

Key activities and outputs

- Four two-hour meetings between February and May 2011;
- Summary report outlining the key issues, current scientific knowledge on those issues, and the implications and recommendations for catchment and water cycle management.

Key topics to be addressed

- Management implications of recent decline in water quality in the estuary, based on Ecosystem Health Monitoring Program (EHMP) scores;
- Explanation and interpretation of outputs from catchment and receiving water modelling projects (current and historical);
- Summary of groundwater knowledge and its management implications, including potential link between a saturated catchment and higher $\delta^{15}\text{N}$ signal;
- Development of whole-of-catchment stream and local-scale sub-catchment mapping (across council borders).

Governance arrangements

- Chair: Dr Peter Schneider (Healthy Waterways);
- Project Coordinator: Dr Mara Wolkenhauer (Healthy Waterways);
- Core members:
 - MBRC: Rainer Haase and Lavanya Susarla;
 - SCC: Graham Webb, Peter Armstrong, Mick Smith;
 - Scientific Expert Panel (SEP): Rod Connolly (deputy chair);
 - Department of Environment and Resource Management (DERM): Mike Holmes;
- Key invited speakers:
 - Mike Holmes (DERM) -> EHMP results and management implications;
 - Tony McAlister (BMT WBM) -> catchment and receiving water modelling;
 - Simon Constanzo (SKM) -> causes and implications of poor $\delta^{15}\text{N}$ results;
 - Malcolm Cox (QUT) -> groundwater knowledge and implications.

Stakeholder communication

- This PPTWG will focus on MBRC's and SCC's local and specific issues only;
- The group will ensure complementarity with the work of existing groups (such as Pumicestone Region Catchment Coordination Association) with an active interest in the health of the Pumicestone Passage;
- PPTWG speakers also presented at the Science Forum in April at the University of the Sunshine Coast;
- A broader group for catchment planning will be assembled in late 2011, which will include community, government and industry stakeholders.

2 List of key issues

Table 1 lists the key issues that were discussed at the meetings, grouped according to whether they relate to measured ecological condition, drivers or management responses.

Table 1: Key issues relevant to recent water quality declines in the Pumicestone Passage

ID	Issue
<i>Condition</i>	
A1	Measured increases in nitrogen concentrations and DIN:TN ratio in central and northern PP
A2	Measured nutrient hot-spots in northern freshwater subcatchments
A3	Measured nutrient hot-spots in southern freshwater subcatchments
A4	Measured decline in seagrass depth range in northern PP
A5	Measured increase in delta 15N in central-northern PP
<i>Key pressures</i>	
B1	Nutrient and sediment runoff from animal and horticultural land use
B2	Nutrient and sediment runoff from proposed Caloundra South Development
B3	Nutrient runoff from on-site sewage systems (septics) in the catchment
B4	Impacts from other known diffuse sources
B5	Nutrient and sediment runoff from numerous small urban developments on water quality (especially construction phase)
B6	Contaminant accumulation due to limited flushing in central-northern PP
B7	Nutrient releases to surface waters from contaminated groundwater
B8	Nutrient and sediment discharges from point sources (e.g. Environmentally Relevant Activities)
<i>Management</i>	
C1	Limited adherence to rural best management practices (BMP) in the catchment

3 Current scientific knowledge and recommendations

3.1 Regional and local ecosystem health monitoring

As part of the Healthy Waterways' Ecosystem Health Monitoring Program (EHMP), trends in water quality across South East Queensland have been monitored monthly over the past decade. The results show that the ecosystem health of the Passage has generally been 'good' (a grade of 'B'). However, since 2008, total nitrogen (TN) has increased in the central and northern section of the Passages, resulting in a continuous decline in the ecosystem health score for the waterway. In 2010, the Passage dropped to its lowest score since the beginning of the EHMP—a 'poor' grade (D+) (Figure).

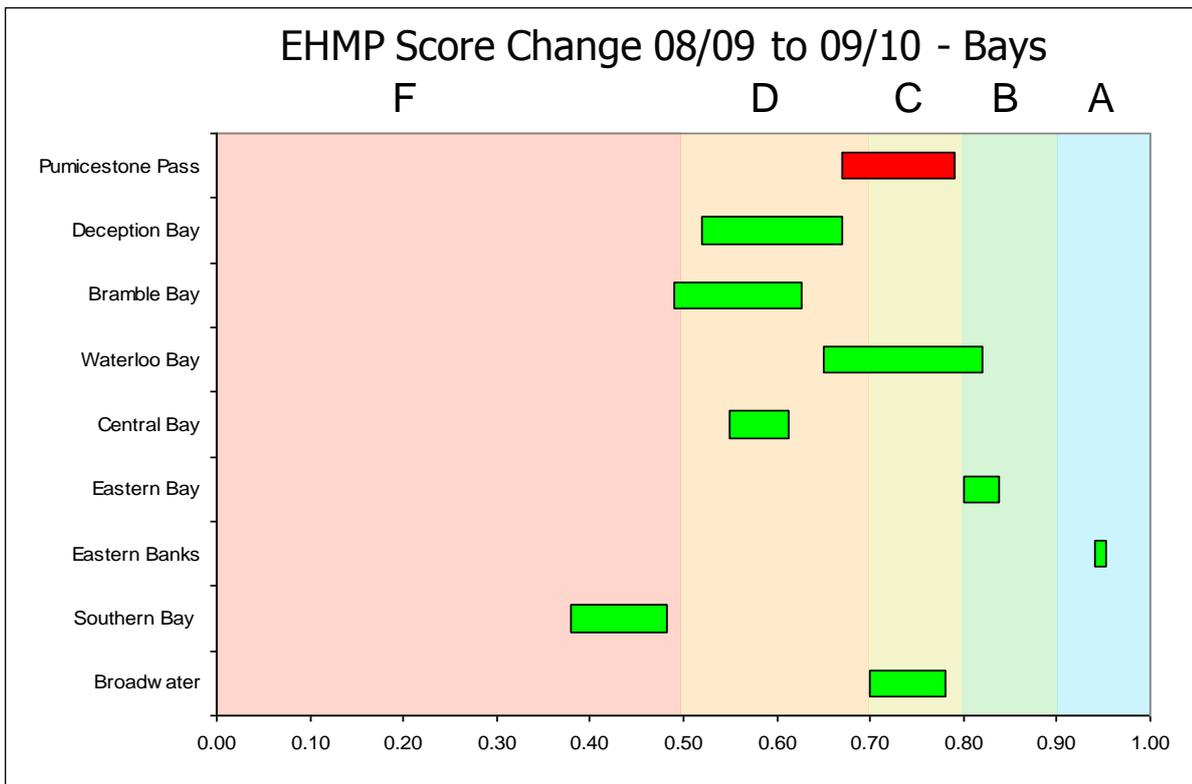


Figure 2: Change in Ecosystem Health Score from 08/09 to 09/10, based on Ecosystem Health Monitoring Program (EHMP) data. Green bars indicating a positive and red bar indicating a negative change. Data sourced from Department of Environment and Resource Management

EHMP data show that the highest nitrogen values within the Passage are found around the mouth of Coochin Creek, in the central-northern reaches, and the ratio between dissolved inorganic and total nitrogen (DIN:TN) has also increased in the same section. Those worsening concentrations have only occurred in the past 3–5 years and only in the central-northern section of the Passage, indicating a local and increasing source of nitrogen.

Data from local monitoring programs undertaken by council staff are also available; however, data collected is mainly restricted to biophysical water quality parameters and has not been collected consistently over the same period. Figure shows SCC's local monitoring sites within tributaries of the central Pumicestone Passage and Table 2 summarises data collected between 2007 and 2009 at those sites.



Figure 3: Location of Sunshine Coast Council's monitoring sites

SCC's local monitoring data was compared with relevant EHMP sites. Oxidised and total nitrogen concentrations were very high in middle to upper Coochin Creek and Back Creek, in the area around Beerwah. There were also site-specific spikes of ammonia and/or dissolved phosphorus in Mellum, Bluegum and Sandy Creeks.

Oxidised nitrogen values between EHMP 1308 in the central-northern Passage (0.01 mg/L), COOC 01 (0.7 mg/L) and EHMP 141-0014 (~2.4 mg/L) showed a very steep increase (70–240 times higher) heading upstream along Coochin Creek. The very high concentrations in middle to upper Coochin Creek and Back Creek were also apparent during dry periods. In comparison, concentrations at sites in tributaries north and south of Coochin Creek were typically less than 0.1 mg/L.

EHMP results show that over time there was a change in the ratio of dissolved-to-total nitrogen in the central-northern section of the passage (but not in the southern section), increasing notably since 2007. This increasing ratio, driven by increasing concentrations of oxidised nitrogen, was not found in the southern section of the Passage over the same period. The group concluded that the Coochin Creek subcatchment is a notable water quality hotspot, and in particular, is a major contributor of total and oxidised nitrogen.

Table 2: Summary results for Sunshine Coast Council's local monitoring program. Values shown are an average of data collected between 2007 and 2009. Results highlighted orange are notably higher than baseline concentrations.

Site	Nox_count	Sal_ppt	Amm_mg/L	Nox_mg/L	OrgN_mg/L	TN_mg/L	DIP_mg/L	OrgP_mg/L	TP_mg/L	Turb_NTU	Fcols_/100mL
BELL01	35	33.0	0.015	0.01	0.26	0.28	0.006	0.020	0.026	5	48
BELL02	52	30.1	0.015	0.01	0.29	0.32	0.006	0.023	0.028	5	105
BELL03	54	25.4	0.018	0.01	0.41	0.44	0.006	0.026	0.032	8	118
BELL04	53	22.3	0.027	0.01	0.45	0.49	0.008	0.022	0.030	6	242
BELL06	53	20.7	0.024	0.01	0.49	0.53	0.007	0.045	0.052	6	277
BELN01	36	21.3	0.027	0.01	0.48	0.52	0.006	0.025	0.030	6	134
LAME01	5	0.1	0.016	0.22	0.87	1.10	0.013	0.092	0.105	4	6515
LAME02	41	17.8	0.030	0.03	0.38	0.44	0.005	0.017	0.022	4	27
PELW01	41	29.4	0.051	0.02	0.25	0.32	0.009	0.031	0.039	3	53
PELW04	41	25.3	0.051	0.02	0.32	0.39	0.005	0.027	0.032	3	31
MAGE02	42	20.1	0.026	0.02	0.42	0.46	0.006	0.030	0.036	1	196
MAGE03	42	18.9	0.073	0.02	0.39	0.48	0.006	0.023	0.029	2	126
PUMI02	42	31.8	0.029	0.01	0.18	0.22	0.006	0.021	0.028	2	23
COOC01	57	13.2	0.042	0.75	0.50	1.29	0.009	0.034	0.044	12	56
COOC02	20	0.1	0.010	2.44	0.56	3.00	0.008	0.023	0.031	9	225
COOC03	61	0.1	0.019	1.91	0.71	2.64	0.009	0.039	0.048	16	475
COOC04	62	0.1	0.034	1.41	0.62	2.06	0.006	0.039	0.044	30	558
COOC05	11	0.1	0.020	0.01	0.31	0.34	0.005	0.054	0.059	19	80
COOC06	33	0.1	0.043	0.09	0.44	0.57	0.006	0.043	0.049	62	1409
MELL01	57	0.3	0.019	0.06	0.43	0.50	0.013	0.075	0.088	21	235
MELL02	42	0.1	0.021	0.05	0.55	0.62	0.022	0.101	0.123	29	2291
MELL03	57	0.2	0.138	0.29	0.49	0.93	0.272	0.152	0.425	31	543
MELL04	53	0.2	0.021	0.01	0.49	0.52	0.010	0.098	0.108	28	265
BLUE01	57	0.1	0.017	0.04	0.54	0.60	0.018	0.086	0.104	15	852
BLUE02	41	0.1	0.019	0.11	0.60	0.73	0.027	0.079	0.106	14	938
BLUE03	51	0.1	0.107	0.08	0.48	0.66	0.041	0.228	0.269	37	201
BACK01	44	0.1	0.023	1.59	0.56	2.17	0.005	0.052	0.058	14	241
BACK02	63	0.1	0.090	2.38	0.90	3.38	0.007	0.036	0.043	16	206
SAND01	62	0.1	0.112	0.95	0.56	1.62	0.005	0.036	0.041	24	481
WALD01	52	0.1	0.039	0.47	0.52	1.02	0.009	0.047	0.055	25	425
COON01	63	0.1	0.032	0.36	0.36	0.75	0.007	0.040	0.046	21	465
TIBR01	13	0.1	0.023	0.18	0.28	0.49	0.005	0.023	0.029	23	57
TIBR02	51	0.1	0.064	0.09	0.43	0.58	0.005	0.039	0.044	39	323
BEER01	62	0.1	0.024	0.03	0.53	0.59	0.019	0.051	0.070	66	5765
80%ile site			0.050	0.60	0.55	1.20	0.015	0.080	0.100	30	550
Qld WQG (lowland FW)			0.020	0.06	0.42	0.50	0.020	-	0.050	50	150

MBRC have monitored local waterways since 1995. However, much of the earlier total nitrogen and phosphorus data are unusable, due to the coarse detection limits that were used. This issue was corrected in 2008. At present, the following parameters are regularly monitored by MBRC:

- Total nitrogen;
- Organic nitrogen;
- Oxidised nitrogen;
- Total phosphorus;
- Filterable reactive phosphorus (FRP);
- Total suspended solids.

Results presented during the PPTWG meetings showed that oxidised nitrogen was very high (6.5 mg/l) at Six Mile Creek, even higher than average values recorded in Coochin Creek in the northern catchment area. While the EHMP results for the Pumicestone Passage indicate no notable effect on water quality in the Passage itself, these very high concentrations indicate a significant local land-use issue with at least local-scale waterway health implications.

A new pilot local monitoring program was established in 2009, which monitors many small estuaries and creeks every 3 months and includes the following biological parameters:

- Phytoplankton (cell counts for ~300 species);
- Cyanobacteria.

Recommendation 1—Design and implement a targeted local monitoring project that complements existing programs and informs development of a nutrient mass balance and estimation of export loads from key land uses. In addition, monitor extra estuarine EHMP sites in estuaries of the Passage, to confirm which tributaries export the greatest nutrient loads.

3.2 Nitrogen isotope ($\delta^{15}\text{N}$) signal in the Passage

The nitrogen isotope signature $\delta^{15}\text{N}$ was developed in the 1990s as a tool to track sewage nitrogen. In recent years, scientists have realised that it is better understood as a tool to track *processed* nitrogen (nitrogen that has been through numerous transformations from its original, atmospheric form). The method cannot be used in isolation and only presents part of the picture when assessing water quality and catchment runoff.

There are three processes that can alter $\delta^{15}\text{N}$: fractionation, volatilisation and microbial processes (that is, denitrification). Denitrification is more likely in wet, saturated soils, enriched with organic nitrogen and carbon, such as those exposed to a high water table.

The highest values measured in the Pumicestone Passage during the EHMP—values greater than 6.7—were found near the mouth of the Coochin Creek estuary, in the central-northern end of the Passage (Figure 4). By way of reference, 6 is typical of septic waste.

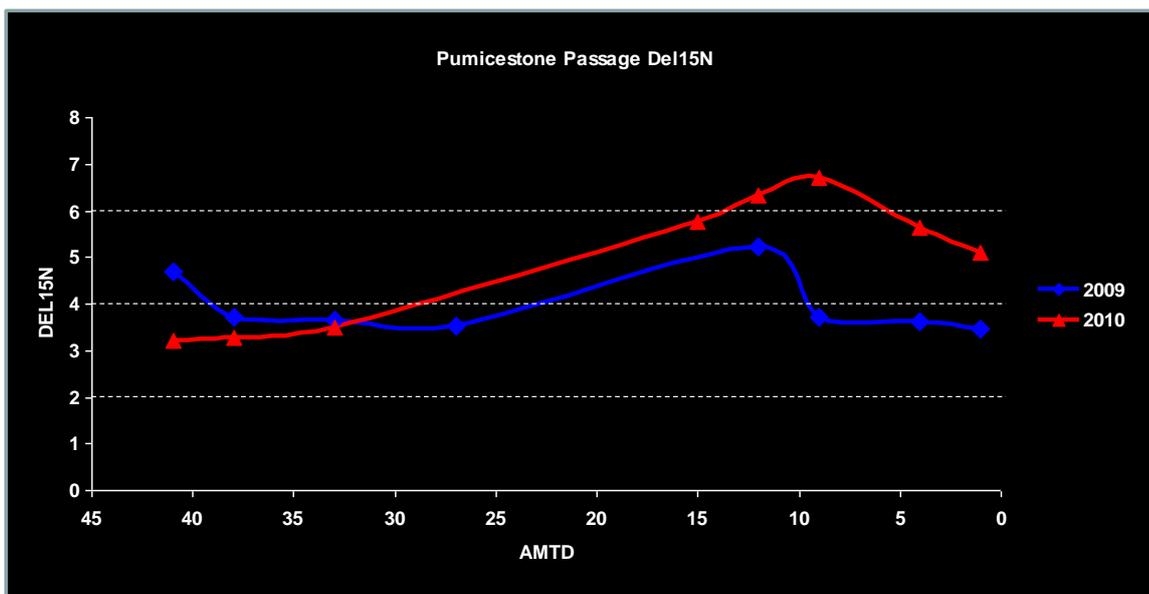


Figure 4: $\delta^{15}\text{N}$ ratio data along the Pumicestone Passage. AMTD = Adopted Middle Thread Distance in kilometres (45 = southern and 0 = northern opening) (DERM data)

The most likely scenario is that higher loads of nitrogen are coming through upper Coochin Creek and are getting processed in the lower Coochin estuary. However, a high $\delta^{15}\text{N}$ value does not necessarily mean more nitrogen in the system; it simply indicates where the nitrogen has come from or how much it has been processed. Therefore, the recent increase in $\delta^{15}\text{N}$ in the northern Passage is probably due to a more-saturated catchment (groundwater and soil) combined with increased nitrogen runoff. The higher $\delta^{15}\text{N}$ signatures measured in 2010 may be primarily due to increased run-off in the preceding years (Figure), and hence, pre-saturation of the catchment; however, conclusive interpretations cannot be drawn from the present data.

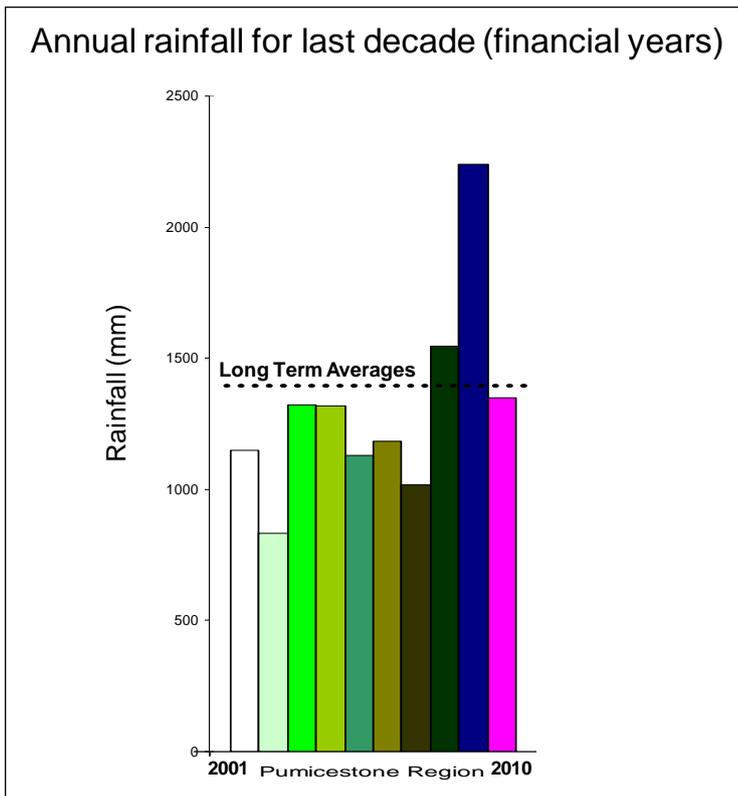


Figure 5: Annual rainfall for the last decade (2001-2010). Dotted line indicates the long-term average (DERM data)

$\delta^{15}\text{N}$ values should be looked at in conjunction with measurements of the percentage of plant or animal tissues present as nitrogen, in order to improve interpretation of results. As part of an integrated assessment along these lines, the correlation between percentage nitrogen and $\delta^{15}\text{N}$ values should be investigated.

Improvement in technical equipment now allows the measurement of $\delta^{15}\text{N}$ directly in water, making the method more accurate and more readily measurable than previously, when measurements were dependent upon the consistent availability of suitable plants, algae or animals.

Recommendation 2—Undertake further investigation into the interpretation of $\delta^{15}\text{N}$ data. In the meantime, spatially-intensive measurements of water column nitrogen are preferred for nitrogen source tracking.

3.3 Water quality modelling in the Passage

Catchment and water quality modelling has been conducted in the Passage over the past decade by a number of organisations in partnership. Building on past models, Healthy Waterways, BMT WBM, CSIRO and eWater CRC have recently developed a coupled Receiving Water Quality Model (RWQM v2) and advanced catchment model (Source Catchments) (<http://www.ewater.com.au/products/ewater-source/for-catchments/>). This coupled modelling system can reproduce and predict water quality in the Pumicestone Passage in wet-, dry- and average-rainfall years, and has been calibrated using EHMP data.

The model is a valuable tool for understanding how and why water quality in Pumicestone Passage has recently declined. It can also predict what the dominant sources of impact on the water

quality are, and how effective various management actions within the catchment may be in preventing or reversing recent declines in ecosystem health.

In addition, a complementary hydrodynamic model was developed by the Groundwater Systems Research team at Queensland University of Technology (<http://www.isr.qut.edu.au/gsr/gvs/>). This groundwater management tool aids in understanding, identifying and communicating groundwater and surface processes, complex sub-surface geology and their various relationships. It aims to provide decision-makers with the conceptual understanding of groundwater systems needed to manage groundwater resources effectively and sustainably. Its ability to animate, interrogate and interact with 3-dimensional models enables a better understanding of the complex nature of the Passage than static images alone and it provides a mechanism for community and stakeholder consultation to support active involvement.

Recommendation 3—Use updated catchment and receiving water quality models and land-use mass balances for the Pumicestone Passage to evaluate potential management strategies in terms of their expected effects on water quality and ecological health.

3.4 Hydrodynamics in the Passage

The question of whether increased nutrient loads in the northern Passage are a result of northward-accumulating loads or localised hot-spot discharges was discussed, with the aid of water quality modelling simulations. The results clearly showed that the northern and southern regions of the Passage are hydrologically distinct, but connected systems. There is a net northern flow along the Passage, and a slack-water zone occurs near the mouth of Coochin Creek where distinct northern and southern tides meet.

The group concluded that the volume of net northward flow does not account for the large increase in nitrogen in the central and northern section of the Passage, thus indicating local input in the vicinity of Coochin Creek. Conversely, these results are not consistent with the alternative explanation, that the high concentrations are a result of uniform runoff from the whole catchment that accumulates from south to north with the net movement of water.

3.5 Land-use changes and mapping in the Passage

The Queensland Land Use Mapping Project (QLUMP) mapped land use across Queensland in 1999, and followed up with a review of the mapping in 2006 (Figure) (<http://www.derm.qld.gov.au/science/lump/>).

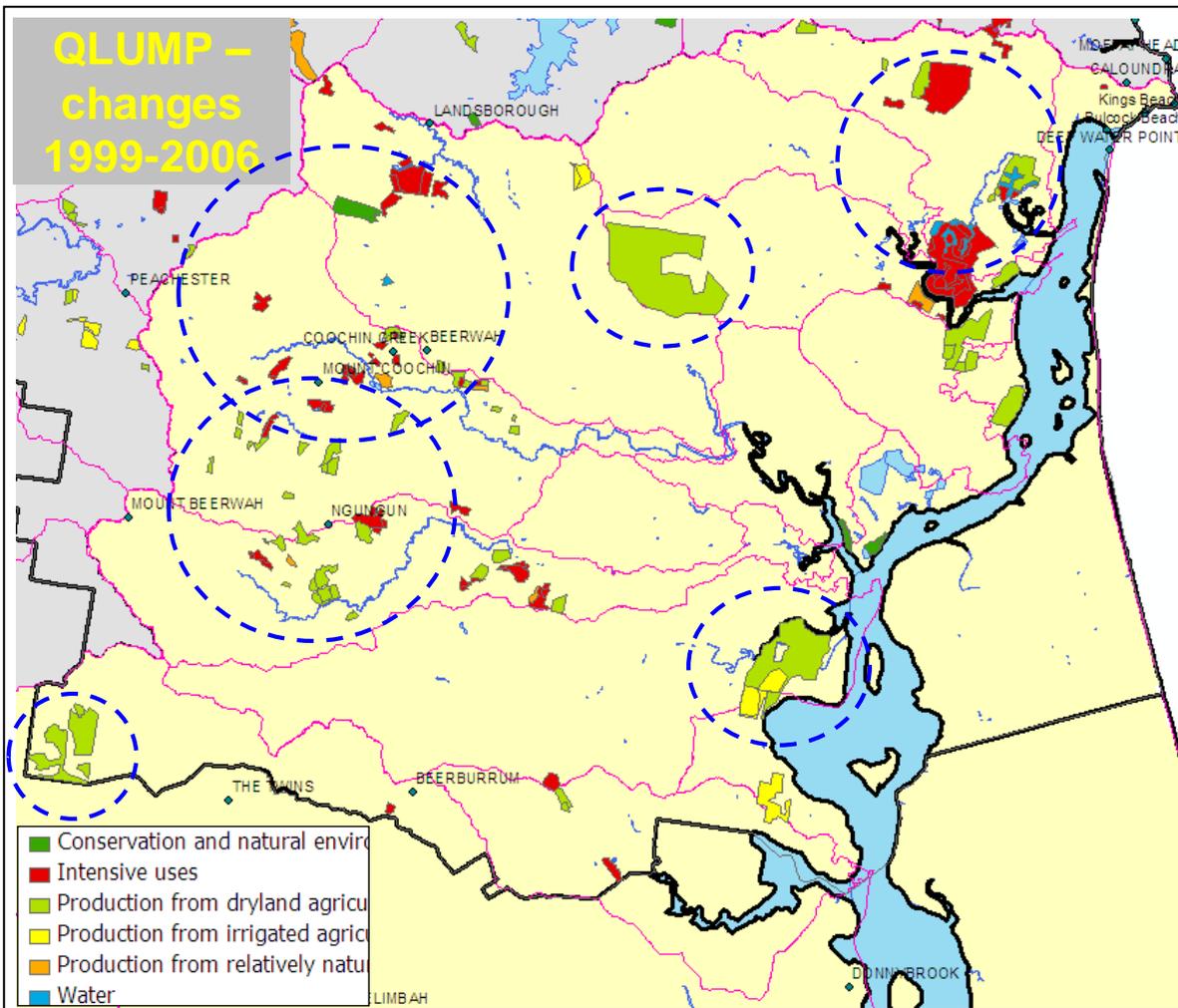


Figure 6: Map of land-use change sourced from Queensland Land Use Mapping Project (QLUMP). Coloured parcels have changed between 1999 and 2006

The group noted that the period of most intense land-use changes (since 2007), and thus of most concern, had not been captured by those recent map updates of land-use change. This crucial knowledge gap had to be filled if any meaningful estimation of catchment input from different land-uses was to be established. Figure and Figure illustrate recent efforts of MBRC, DEEDI and others to develop updated land-use mapping within the Pumicestone Passage catchment, based on recent aerial photography and other ground-truthing activities.

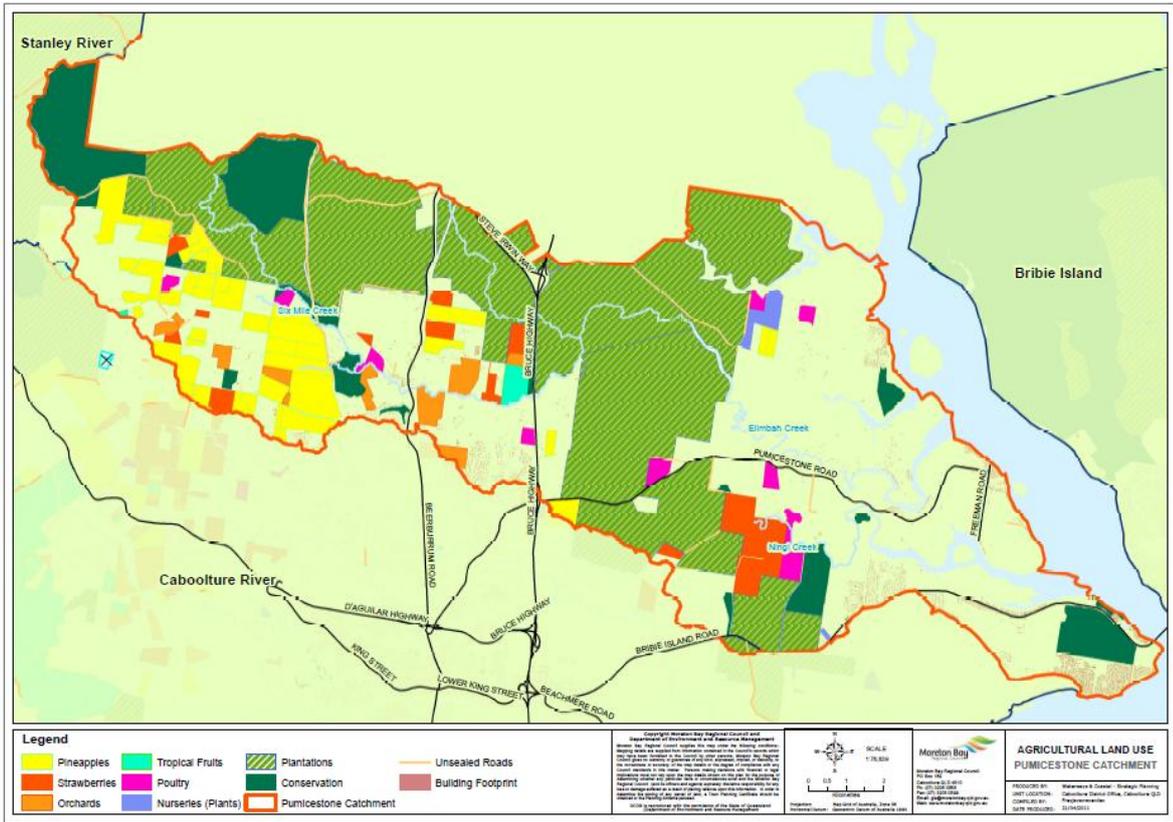


Figure 7: Agricultural land-use map from Moreton Bay Regional Council for the southern part of the Pumicestone Passage catchment

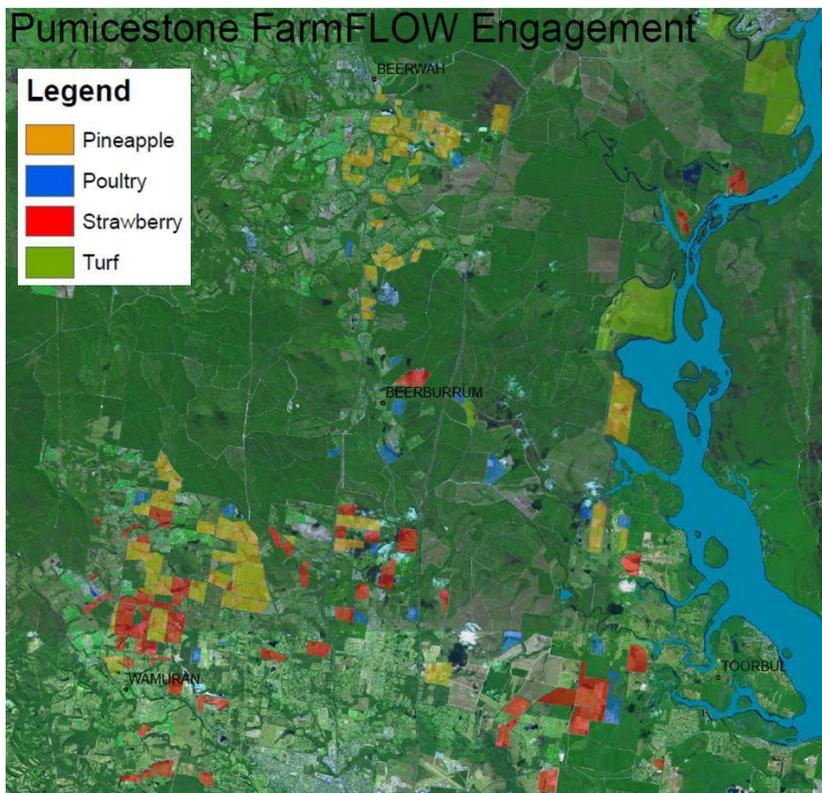


Figure 8: Map of confirmed agricultural land-use parcels in the northern Pumicestone Passage catchment. Sourced from FarmFLOW project (SEQ Catchment and DEEDI)

Mapping showed that presently, the most common agricultural land uses in the Pumicestone catchment (excluding forestry) are pineapples, poultry, strawberries and turf. Changes in land use

since 1999 have typically involved intensification of land-use, to more intensive farming such as the activities above, as well as increasing urbanisation.

Recommendation 4—Develop a single, accurate land-use map of the Pumicestone Passage catchment.

3.6 Nutrient sources in the Passage

The catchment of the ecologically-important Pumicestone Passage is an area of high growth, and special attention is needed when further expanding the urban footprint, if it is to be expanded at all. Major changes to land uses and increased habitat fragmentation have significant impacts on biodiversity and overall ecosystem health. In order to achieve suitable water quality outcomes, and to reverse the recent trend of additional nitrogen loads entering the system, ‘beyond best practice’ management measures are required for both urban and agricultural activities. Listed below are some key mitigation activities or data gaps that the group discussed and considered important to address:

Urban developments—

- Erosion and sediment control during and post-construction (particularly the proposed large-scale Caloundra South development);
- Audits and enforcement of construction regulations;
- Audits of on-site sewage systems (septics) and incentives to connect to reticulated sewerage;

Agriculture—

- Estimating nutrient loads entering waterways at different points along the catchment and the relative loads coming out of each land-use (estimating largest contributors);
- Local expert review and ground-truthing of recorded land-use data and development of updated land-use distribution maps to determine recent land-use changes;
- Developing a mass-balance or budget for total nitrogen loads from the catchment;
- Acknowledging socio-economic aspects and implications in relation to tracking the uptake of best management practices in the agricultural sector;
- Extending and increasing current incentive programs that encourage farmers to adopt best management practices.

Recommendation 5—Implement regulatory and incentive-based measures to ensure adequate erosion and sediment control during the construction phase and environmentally-sensitive urban design for any new developments in the catchment, in particular, large-scale developments such as Caloundra South.

Recommendation 6—Develop a mass balance for nutrient, sediment and pathogen loads generated from the catchment by agricultural activities, especially pineapple, strawberry, turf and chicken farms and unsealed roads, to identify the major contributors.

Recommendation 7—Implement incentive-based and regulatory measures to improve management of agricultural activities within the catchment, in particular, pineapple, strawberry, turf and chicken farming and waste disposal.

3.7 Environmentally relevant activities

A variety of environmentally relevant activities (ERAs) take place in the Pumicestone Passage catchment. These are activities regulated under the state *Environmental Protection Act 1994*. However, there are no significant wastewater discharges, and none of the activities were considered to present a significant threat to water quality in the Passage.

Australia Zoo is a well-known ERA near Beerwah. It was of interest to the group because of its location within the established nutrient hot-spot zone, its expected high volumes of human and animal waste, and the fact that a tributary of the Pumicestone Passage runs right through the site.

In 2007, the Zoo hosted about 1000 staff and volunteers, up to 6,000 animals and more than one million annual visitors. The Zoo site has grown significantly, from around 2 hectares in 1970 to about 28 hectare in 2006, and an expansion to 400 hectare was planned after 2008, with its most recent expansion involving a land-swap with forestry. There has not been significant clearing at the site in the past few years. The Zoo's human waste is sewered and treated at the Landsborough Sewage Treatment Plant. The Zoo's animal waste and water discharges from the ponds are not regulated and currently fall under the duty of care of the organisation.

Local water quality monitoring indicates some potential localised nutrient inputs into Bluegum Creek from the Zoo, but not substantial enough to be driving recent poor results much further downstream, in the Passage.

Recommendation 8—Liaise with Australia Zoo to determine the quantity of any nutrient loads released to Bluegum Creek or other streams, and assist implementation of improved practices if required.

3.8 Chicken farms in the Passage

Chicken farming has been a contentious issue within the Pumicestone Passage, and may be a significant contributor of nitrogen and other contaminants to the Passage. The group discussed this issue with the aid of information from a desktop study on the issue that has recently been conducted by Moreton Bay Regional Council, data provided by Rob King (Sunfish) and an audit and report conducted recently by DEEDI (FSA, 2010).

It was noted that DEEDI also made some additional data available to council from more recent investigations. Key conclusions and concerns were:

- The overall load of poultry waste was estimated at 55,800 t/yr;
- Approximately 7,000 t/yr of poultry waste are not accounted for and may enter the Passage via aerial dispersion;
- 30% of the overall poultry litter stays in the Passage, where it is used as organic fertilizer for turf, strawberries, tree crops, etc; 70% of litter is exported from the catchment;
- Regular tracking and management of poultry litter loads needs to be conducted.

The possibility of commencing open dialogue and negotiations with the poultry farms was discussed. An advantage is that only two major companies (Inghams and Steggles) hold 90% of Queensland market share for poultry farms, and that the president of the Queensland Chicken Growers Association is a local farmer within the catchment.

See Recommendations 6 and 7.

3.9 Pine plantations and other forestry activities

Pine plantations, administered by Forest Plantation Queensland (FPQ) from their Beerburrum office, cover about 25,000 hectares within the Pumicestone catchment (Figure), of which only 400-800 hectares are harvested each year. This is FPQ's second largest estate and they are the largest 'single' land user in the Pumicestone Catchment.

The PPTWG investigated and discussed recent clearing (2006-2011), fertilizer application, recreational use and other issues relevant to potential impacts on local waterway health. A map is presented (Figure), highlighting all areas where new planting occurred in the last 5 years. Based on the map, the following conclusions were made:

- The overall cleared area, compared to total forestry area, is relatively small (<10%);
- The largest area of forest cleared in the past 5 years was on northern Bribie Island (in 2007)
- No active clearing occurred between 2008-2010.

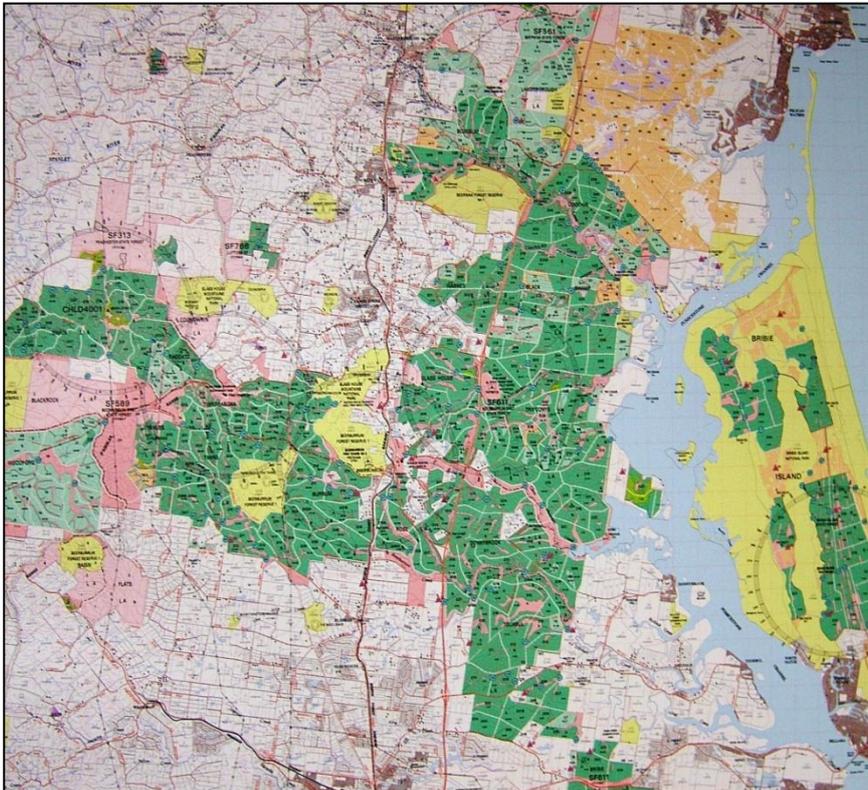


Figure 9: Pine Forestry Plantations in the Pumicestone Passage Catchment. Photograph of FPQ map. Green= active forestry; pink= buffers; yellow= state/conservation; red= active forestry, cleared and planted within the past 5 years; salmon = cleared and not active forestry



Figure 10: Recently cleared Pine Forestry Plantations in the Pumicestone Passage Catchment (2007-2010) (red areas). Photograph of FPQ map

FPQ Beerburrum’s major activities are plantation harvesting, re-establishment, weed control, prescribed burning and road maintenance. FPQ has put in place a water quality monitoring program and measures to ensure watercourse protection, soil protection, native forest protection and pest management. Fertilizer application is only undertaken 2–3 times in the 30-year lifespan of a plantation—a general application one year before planting, and a direct application to the trees a few years after planting. FPQ is using its own models to work out optimal use of fertiliser for their plantations and to assess its potential impact on water quality in the Passage.

The group considered that FPQ’s management practices were sufficient to avoid significant impacts on the health of the Passage. Further, it was noted that forestry has been consistently practiced across the catchment over several decades, with no significant changes or intensification in recent years. Therefore, the group concluded that forestry has not been a major contributor to the recent decline in local water quality.

However, recreational use of forestry plantations was noted as a potential threat to local water quality. Roads between the plantation blocks are frequently used by 4-wheel-drives, contributing to sediment runoff from unsealed roads and, in particular, from along road verges. This can substantially contribute to sediment and sediment-bound nutrient run-off from forestry areas. The need for ongoing discussion between councils and FPQ was noted, especially concerning future clearings, controlling recreational use and limiting illegal waste dumping in forestry areas.

See Recommendation 6.

Recommendation 9—Initiate on-ground projects to mitigate impacts from unsealed roads.

Recommendation 10—Develop a management plan and compliance program for 4-wheel-drive vehicles within forestry and other areas.

4 Current management activities

4.1 Total water cycle management planning

Total water cycle management planning (TWCMP) is an issue-based identification of potential solutions to whole-of-catchment water management, which is being applied in the southern Pumicestone Passage catchment by Moreton Bay Regional Council.

This work has a strong emphasis on water supply, but it is broader and involves understanding all the drivers of a whole-of-catchment approach and how water relates to it. The key themes considered through TWCMP are:

- natural cycles of waterways;
- sustainable limits of extraction, discharge and flows;
- water conservation, diversity and supplies; and
- overall water quality.

Catchment auditing of existing and future issues and water have been undertaken as part of this planning exercise. Other data such as population growth pressure, water supply drivers, environmental flow, climate change impacts, water conservation targets, wastewater, and water quality and quantity are also being considered.

A series of workshops with stakeholders has been undertaken to discuss potential options that could be applied. An example of how this can be applied is a multi-criteria assessment, using expert elicitation, ranking various strategies and short-listing potential solutions and ultimately recommending a list of solutions tailored to each catchment.

4.2 Catchment and estuary management planning

Sunshine Coast Council endorsed its *Waterways and Coastal Management Strategy 2011–2021* in February, 2011. The Strategy outlines the nature and values of the region's waterways and catchments, including the Pumicestone Passage, the challenges or issues to be addressed in managing them, and strategic outcomes (broad management responses) for achieving its vision, that:

the Sunshine Coast's waterways and coastal foreshores are ecologically healthy, well-managed assets that underpin our livelihoods and lifestyles.

Catchment and estuary management plans (CEMPs) have been identified as the key mechanism for achieving the strategic outcomes and vision of the Strategy. CEMPs will be developed for each of the Sunshine Coast's major river catchments. In particular, a CEMP for the Pumicestone Passage catchment is being progressed as a priority during 2011, due to the ecological importance and declining ecosystem health of the system.

Through the CEMP for the Pumicestone Passage, waterway management issues will be identified and prioritised, and suitable management actions, costs and timelines will be developed for priority issues. The plan will consider:

Social issues—the sustainable use of our waterway for both active and passive recreational and leisure activities and the protection of the cultural and creative significance of waterways;

Environmental issues—protection and improvement of waterway health by addressing diffuse and point sources of pollution, extent and condition of riparian vegetation, bank stability and aquatic biota;

Economic issues—support for the maintenance and growth of waterway dependent tourism and commercial industries, including both on-river operations and businesses adjacent to waterways, which contribute to Sunshine Coast economy.

The resulting Pumicestone Passage Catchment & Estuary Management Plan (CEMP) will be a set of actions to be carried out over three years by numerous partners, which will reduce current impacts on catchment and waterway health.

Key steps in the development of the CEMP will be:

- Review data, including existing plans and strategies;
- Identify community and industry stakeholders;
- Develop draft catchment and estuary management plan in partnership with the state government and community and industry stakeholders;
- Undertake broad community consultation on the plan;
- Finalise catchment and estuary management plan;
- Implement catchment and estuary management plan.

This TWG report forms an important component of the background information for the CEMP (step 1 above), along with a Science Forum conducted in April (SEQ Catchments, 2001), and a wealth of other science and planning information from decades of cooperative management of the catchment, including a previous catchment management strategy (PRCCA, 2000). The consultation phase for the Pumicestone Passage CEMP (steps 2–4 above) is scheduled to begin in late 2011, with finalisation of the plan (steps 5–6) in 2012.

5 References

FSA Consultants (2010). *Audit of spent litter production and utilization—Pumicestone catchment*. DEEDI

Pumicestone Region Catchment Coordinating Committee (PRCCA; 2000). *Pumicestone Region Catchment Management Strategy*. Queensland Department of Natural Resources

SEQ Catchments (2011). *What we know about the Pumicestone—Current science of the Pumicestone Passage*. SEQ Catchments

Appendix A – Table of learnings

Issue ID	Issue	TWG learnings (from presentations and discussions)	Desired learnings—short-term (what we should investigate in 2011)	Investigations and methods (for desired short-term learnings)	Desired learnings—future (what we should investigate >2011)	Issue significance (level; why?)
A: CONDITION (indicators relevant to declining ecosystem health report card grades in the PP estuary)						
A1	Measured increases in nitrogen concentrations and DIN:TN ratio in central and northern PP	<ul style="list-style-type: none"> • Total nitrogen (TN) has increased in the central and northern section of PP since 2008 • Highest values are found around mouth of Coochin Creek • DIN:TN ratio has increased recently in central-northern PP due to proportionately higher DIN concentrations • Most notable changes have occurred in past 3-5 years • Combined observations suggest local source in northern PP rather than accumulation due to net northward flow 	<ul style="list-style-type: none"> • Where is the increased local DIN and TN coming from? • Spatial origins (see A2) • Major land-use sources (see A2) • Has rainfall delivered more nutrients or are there more to deliver? 	<ul style="list-style-type: none"> • Spatially-intensive monitoring (see A2) • Desktop study on local source estimates • Data collection to improve modelling capacity, RWQM v3 • Assess correlations between local rainfall and increased N concentrations 	<ul style="list-style-type: none"> • Response of N concentrations to management actions and/or ongoing land-use issues 	HIGH; declines in this indicator have driven recent report card grade declines

Issue ID	Issue	TWG learnings (from presentations and discussions)	Desired learnings—short-term (what we should investigate in 2011)	Investigations and methods (for desired short-term learnings)	Desired learnings—future (what we should investigate >2011)	Issue significance (level; why?)
A2	Measured nutrient hot-spots in northern freshwater subcatchments	<ul style="list-style-type: none"> Very high nitrogen oxides (NO_x) & TN concentrations measured in middle-upper Coochin Ck and Back Ck (predominantly rural) 	<ul style="list-style-type: none"> Specific land uses contributing to locally-high N concentrations 	<ul style="list-style-type: none"> Wet- and dry-weather intensive spatial TN and DIN sampling within hotspot area Plot-level verification of GIS land-use layer 	<ul style="list-style-type: none"> Response of N concentrations to management actions and/or ongoing land-use issues 	HIGH; to pinpoint land uses affecting key report card indicator
A3	Measured nutrient hot-spots in southern freshwater subcatchments	<ul style="list-style-type: none"> Very high oxidised nitrogen (NO_x) & TN concentrations measured in Beerburrum Ck and Six Mile Creek 	<ul style="list-style-type: none"> Specific land uses contributing to locally-high N concentrations 	<ul style="list-style-type: none"> Desktop study on local source estimates including sewerage leaks/overflows Analyse overflow data from Unitywater 	<ul style="list-style-type: none"> Response of N concentrations to management actions and/or ongoing land-use issues 	MODERATE; may contribute to cumulative impacts via N flow
A4	Measured decline in seagrass depth range in northern PP	<ul style="list-style-type: none"> Seagrass depth range declined in the northern PP in 2010 	<ul style="list-style-type: none"> Is this the start of a consistent decline or an expression of year-to year variability? 	<ul style="list-style-type: none"> Continued EHMP monitoring and data interrogation; especially 2011 report card Analyse Seagrass watch data 	<ul style="list-style-type: none"> Will seagrass recover if N-levels are restored? Long-term relationship with other indicators (e.g. turbidity) 	LOW; priority will increase if consistent declines measured

Issue ID	Issue	TWG learnings (from presentations and discussions)	Desired learnings—short-term (what we should investigate in 2011)	Investigations and methods (for desired short-term learnings)	Desired learnings—future (what we should investigate >2011)	Issue significance (level; why?)
A5	Measured increase in delta 15N in central-northern PP	<ul style="list-style-type: none"> • Increase in del 15N ratio in the northern section of PP since 2008 • Relationship of this indicator to land-use changes is more complicated than TN 	<ul style="list-style-type: none"> • Spatial distribution of delta 15N values in northern tributaries 	<ul style="list-style-type: none"> • Intensive local spatial snapshot; measuring del 15N directly in water • Continued EHMP monitoring and data interrogation 	<ul style="list-style-type: none"> • Will delta 15N drop back to previous levels? • Long-term relationship with other indicators (e.g. TN/DIN) 	LOW; will be addressed by managing TN; but research still desirable
B: KEY PRESSURES (relevant to indicators behind report card grade declines)						
B1	Nutrient and sediment runoff from animal and horticultural land use	<ul style="list-style-type: none"> • Number of chicken farms and waste volumes have increased in recent years (Rob King data) • Chicken farm contaminants may enter waterways through aerial route or application of waste manure as fertiliser • There has been an increase in intensity and types of agricultural land-use in the last 3–5 years (away from cane & horticulture; towards turf, strawberries and chooks) 	<ul style="list-style-type: none"> • Fate of all waste (within and/or outside of PP catchment) • Estimated loads entering waterways from various sources • Largest contributors of N by area and total load • Up-to-date and accurate agricultural land-use mapping 	<ul style="list-style-type: none"> • Follow-up on DEEDI chicken litter audit to identify wastes not initially accounted for • Desktop study on land-use load estimates • Local expert review and ground-truthing of recorded land-use data • Develop a mass-balance or budget 	<ul style="list-style-type: none"> • Changes in nutrient and sediment generation from various industries after adopting better practices 	HIGH; potentially the key driver of increasing nutrient loads

Issue ID	Issue	TWG learnings (from presentations and discussions)	Desired learnings—short-term (what we should investigate in 2011)	Investigations and methods (for desired short-term learnings)	Desired learnings—future (what we should investigate >2011)	Issue significance (level; why?)
B2	Nutrient and sediment runoff from proposed Caloundra South Development	<ul style="list-style-type: none"> • Environmental constraints are: water supply; wastewater discharge; PP water quality • Beyond best practice is required to maintain water quality in PP • Stockland WQ modelling indicates likely increase in P in Bells Ck but no notable nutrient increases in PP 	<ul style="list-style-type: none"> • Refine understanding of likely impacts from the proposal • Assess likely effects of management actions across catchment on PP water quality • Confirm feasibility and adoption of beyond-BP practices to mitigate Construction-phase impacts 	<ul style="list-style-type: none"> • Run WQ modelling scenarios • Continued local WQ monitoring • Review QWC sub-regional plan for potential information to fill current knowledge gaps 	<ul style="list-style-type: none"> • Measured impacts during and post-development (especially concerning WQ in Bells Creek) 	MODERATE; local nutrient increases likely
B3	Nutrient runoff from on-site sewage systems (septics) in the catchment	<ul style="list-style-type: none"> • Total number has reduced recently, due to connection to main sewers • Around 20% of audited septic systems in SCC area showed some non-compliance (400 of 2,000) 	<ul style="list-style-type: none"> • Estimate of potential nutrient and pathogen loads to PP 	<ul style="list-style-type: none"> • Desktop analysis of estimated loads entering local waterways • Mass-balance • Review data from ongoing SCC auditing program 	<ul style="list-style-type: none"> • Changes in compliance with ongoing extension, auditing and regulation 	MODERATE; some nutrient inputs but overall loads not expected to be major

Issue ID	Issue	TWG learnings (from presentations and discussions)	Desired learnings—short-term (what we should investigate in 2011)	Investigations and methods (for desired short-term learnings)	Desired learnings—future (what we should investigate >2011)	Issue significance (level; why?)
B4	Impacts from other known diffuse sources	Nutrients, sediment and pathogen runoff expected from: <ul style="list-style-type: none"> • Unsealed roads & recreational-vehicle access • Reticulated sewerage leaks/overflows • Forestry areas • Bribie Island streams 	<ul style="list-style-type: none"> • Estimated loads entering waterways from various sources • Largest land-use contributors of N and other contaminants by area and total load 	<ul style="list-style-type: none"> • Desktop analysis of estimated loads entering local waterways • Refined WQ/catchment modelling 	<ul style="list-style-type: none"> • Spatial distribution of loads from any other notable sources 	MODERATE; may be notable inputs from forestry and sewerage but overall loads not expected to be major
B5	Nutrient and sediment runoff from numerous small urban developments on water quality (especially construction phase)	<ul style="list-style-type: none"> • Beyond best practice erosion and sediment control and WSUD desirable to prevent worsening of local and PP water quality 	<ul style="list-style-type: none"> • Number and size of developments, distribution, performance and risks to receiving waters 	<ul style="list-style-type: none"> • Control and impact monitoring program (e.g. erosion and sediment audits) 	<ul style="list-style-type: none"> • Risk assessments on diffuse load sources 	LOW; no evidence of widespread increases in sediment loads, etc
B6	Contaminant accumulation due to limited flushing in central-northern PP	<ul style="list-style-type: none"> • The north and south region of the passage are hydrologically different, but connected systems • There is a net northern flow along the Passages • There is a dead-zone around Coochin creek where north and south tides meet 	<ul style="list-style-type: none"> • What would pre-European WQ have been in the dead-zone? 	<ul style="list-style-type: none"> • WQ modelling to assess all-natural land-use scenario • Adjustment of EHMP guidelines if necessary to reflect expected natural water quality 	<ul style="list-style-type: none"> • 	LOW; possible issue for EHMP guidelines; to be addressed in program review

Issue ID	Issue	TWG learnings (from presentations and discussions)	Desired learnings—short-term (what we should investigate in 2011)	Investigations and methods (for desired short-term learnings)	Desired learnings—future (what we should investigate >2011)	Issue significance (level; why?)
B7	Nutrient releases to surface waters from contaminated groundwater	<ul style="list-style-type: none"> Complex interaction between groundwater and surface water within PP catchment 	<ul style="list-style-type: none"> Are groundwater inputs significant relative to surface run-off? 	<ul style="list-style-type: none"> Assessment of whether land-use and catchment modelling can adequately predict surface WQ 	<ul style="list-style-type: none"> If surface water quality modelling shown to be deficient, need a catchment-wide model linking ground- and surface-water 	LOW; managing land use and surface water quality expected to address groundwater quality issues
B8	Nutrient and sediment discharges from point sources (e.g. Environmentally Relevant Activities)	<ul style="list-style-type: none"> Australia Zoo's onsite human waste is sewered and regulated; volume of animal waste is currently unknown and unregulated No sewage treatment plant or other major industrial discharges in catchment 	<ul style="list-style-type: none"> Animal waste disposal practices at Australia Zoo 	<ul style="list-style-type: none"> Partnership between council and zoo to share monitoring data Collaborations with FarmFLOW project 	<ul style="list-style-type: none"> 	LOW; no major point-source nutrient inputs identified
C: MANAGEMENT (limited issues presented here as this process focused on providing an <i>input</i> into management/planning)						
C1	Limited adherence to rural best management practices (BMP) in the catchment	<ul style="list-style-type: none"> Some agricultural activities have 30% or less uptake of BMP (e.g. pineapple farms) 	<ul style="list-style-type: none"> Socio-economic implications in relation to monitoring and improving BMP uptake 	<ul style="list-style-type: none"> Ongoing auditing Finding innovative, different approaches and collaborations 	<ul style="list-style-type: none"> Changes in uptake of BMP with ongoing extension and incentive programs (DEEDI) 	HIGH; relevant to management of a key driver of increasing nutrient loads